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American Welding Society

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AMERICAN WELDING SOCIETY
ESTABLISHED 1919
JOURNAL

Volume 4 November, 1925 Number 11

OVER 5000 SEE WELDING EXHIBITS

The greatest fall meeting in the history of the American Welding Society was held in Boston on Oct. 21, 22 and 23 at the Massachusetts Institute of Technology. Executives and engineers from many industries from the New England and Eastern States were present at the various technical sessions and exhibits, as well as representatives from other parts of the country.

Amazement was expressed not only by experts from allied industries but even by those associated with the welding industry as to the extension of the numerous applications of welding during the past two or three years. This phase was stressed particularly in the technical papers. Welding is becoming one of the most important manufacturing means available today. The several processes of welding are fast replacing riveting and castings in hundreds of different industries.

The outstanding feature of this fall meeting was the remarkable success of the first welding exhibit staged by the Society. Twenty-five exhibitors demonstrated the new developments in apparatus and materials that have been made during the past few years. These exhibits enabled prospective users of welding to receive first hand demonstrations of what could be done in the welding and cutting field by the several processes.

The selection of M. I. T. as headquarters for the Society meeting was particularly fortunate. Not only were adequate facilities such as space, lecture rooms and services provided for both exhibits and technical sessions, but it also enabled the engineering faculty and students of this college to acquaint themselves with what is going on in the welding field and what could be done through the use of welding.

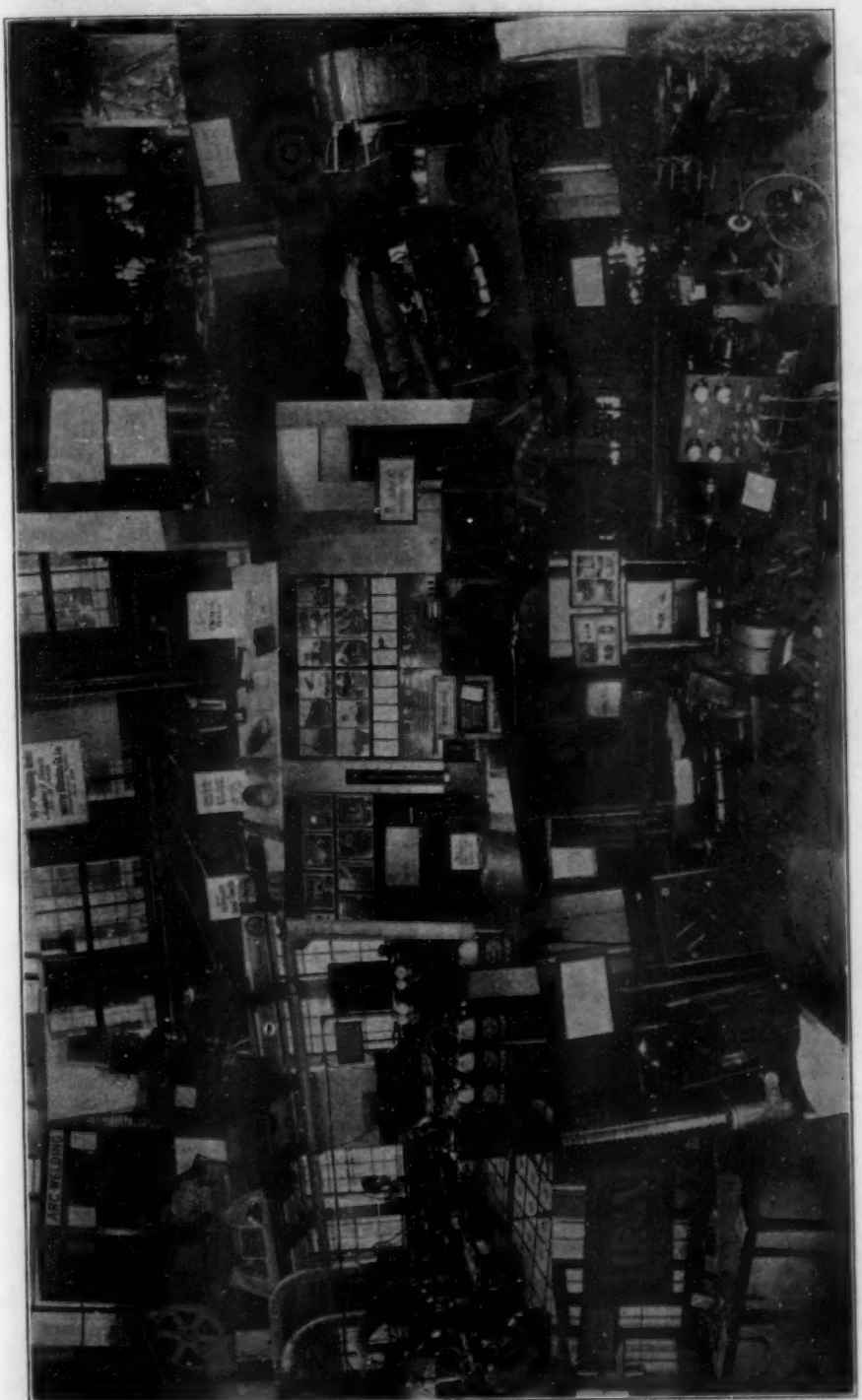
Another unusual feature of this meeting was the attendance of the ladies. A number of items were scheduled for their entertainment. A sight-seeing bus trip was arranged on Thursday afternoon to many points of interest in Boston and its vicinity. Over thirty ladies took advantage of the opportunity to see the many historic points of interest in Boston including Boston Common, Faneuil Hall, Christ Church, Old State House, the site of the Boston Tea Party, Bunker Hill Monument and points of interest in Lexington and Concord. Their presence at the annual Fall Dinner and Theater Party helped to make these events an outstanding success and one that will be long remembered by the members of the Society and their friends.

The fall meeting was formally opened on Wednesday morning, Oct. 21, with a paper on "Thermit Welding," by J. H. Deppeler, chief engineer, Metal and Thermit Corporation. Mr. Deppeler reviewed the progress made during the last few years in thermit welding. A very substantial reduction in costs and improvement in quality of welds have been brought about through concentrated research efforts of the Metal and Thermit Corporation.

In the afternoon on the same day the meeting was officially opened by Mayor Quinn of Cambridge, who welcomed the members of the Society and their guests to Cambridge and pointed out the fact that Cambridge was an educational center of note throughout the world. A. W. Moulder, chief engineer of the Grinnell Company, presented a paper on "Gas Welding of Power Plant Piping," in which he demonstrated the superiority of welding over other methods of pipe installation both as to cost and quality of product. As an illustration, a welded high pressure steam header for a battery of several boilers and with outlets for several connections for turbine cost $332 as compared with $1,034 as the cost of a header for the same purpose with lap joint flanges and cast steel fittings.

Wednesday evening was given over

Welding Exhibits at Annual Fall Meeting, American



Welding Society, Boston, Oct., 1925

to demonstrations by the exhibitors. Several thousand people took advantage of this opportunity to visit the booths of some of the leading manufacturers in the welding field. Entertainment was provided in the form of a buffet dinner served at the dining room of the M. I. T. The dinner was enjoyed by about 300.

On Thursday morning, Oct. 22, a paper was presented by H. M. Hobart and W. Spraragen, chairman and secretary, respectively, of the electric arc welding research committee of the society. These authors stressed the numerous existing applications of arc welding in our various industries. In some of the larger manufacturing companies it is saving hundreds of thousands of dollars annually. The important elements governing the adoption of welding were also briefly discussed.

Thursday afternoon was devoted to a meeting of the American Bureau of Welding, which is the research department of the American Welding Society. M. Holland, director of the Division of Engineering and Industrial Research of National Research Council, presented an address on the "Industrial Picture Viewed Through a Focus of Research." That research is a paying proposition was clearly brought out by Mr. Holland, who has had an unusual opportunity to study the importance of research as an industrial aid. Prof. C. A. Adams, director of the American Bureau of Welding, interpreted what research has done for the welding industry and what it can still do if properly applied. W. Spraragen, secretary of the bureau, pointed out some of the investigations about to be undertaken if suitable financial support could be secured. These cover pressure vessels, survey of the welding industry and the welding of steel structures. Reports of research committee chairmen brought out that a great deal of investigational work has been in progress by the bureau during the past year. These have yielded results of immense importance to the welding industry and allied industries employing welding.

The annual fall dinner was held at the Hotel Somerset on Thursday evening, Oct. 22. Nearly 250 members and their guests, including a number of ladies, enjoyed the excellent dinner arranged for this occasion. There were several after dinner speakers, among whom were included Hon. James Curley of Boston; Prof. E. F. Miller, Massachusetts Institute of Technology; Prof. Elihu Thomson, General Electric Co.; Prof. C. A. Adams, Harvard University; Prof. A. S. Kinsey, Stevens Institute of Technology. Music was furnished by Dyk's Esquimaux Orchestra. Speeches and music were broadcasted from station WNAC. Following the dinner members and guests were transported by a fleet of taxicabs to the Shubert Theater. "The Student Prince" proved to be highly entertaining and a fitting climax for the occasion.

The Friday morning session was

devoted to a series of several addresses on "Materials for Welding." These speakers included J. R. Dawson, metallurgical engineer, Union Carbide and Carbon Research Laboratories, on "High Strength Welds"; H. M. Carter, "Control of Manufacture and Acceptance Tests of Welding"; C. A. McCune, "Welding Wire a Factor in Good Welding," and C. J. Holslag, "Metallic Arc Weldability of Ferrous Metal." This session aroused a great deal of discussion and brought out the importance of welding wire in producing good welds.

The concluding session of the fall meeting was held on Friday afternoon, at which time J. W. Meadowcroft, supervisor of welding of the E. G. Budd Manufacturing Co., presented a review on the "Manufacture of All Steel Automobile Bodies." This was illustrated by a moving picture showing details of the application of spot welding, gas and electric welding, in the production of automobile bodies on a large scale. Methods, technique, jigs and fixtures have become highly standardized and have resulted in quantity production with accompanying high quality of product.

During the convention, luncheon was served at cost to members at the restaurant in the Walker Memorial Building of Massachusetts Institute of Technology.

INTERNATIONAL ACETYLENE ASSOCIATION

The International Acetylene Association will hold its twenty-sixth convention at Congress Hotel, Chicago, Ill., on Nov. 18, 19 and 20. The program for Wednesday, Nov. 18, includes the president's address, secretary's report, addresses on "Acetylene: Beacon of Progress," by E. E. Thum; "Surveying an Industrial Plant and the Installation of Oxygen and Acetylene Piping," by W. A. Slack; "Procedure Control in Welding," by L. E. Ogden; "Influence of Oxy-Acetylene Cutting on Steel Foundry Practice," by R. W. Thomas; "The Part Played by Acetylene in Warship Scrapping," by Commander H. E. Roselle; "Effect of Heat of Bronze Welding on Cast Iron Pipe," by A. R. Lytle; "Welding of Carbon and Alloy Steel Tubing for Aircraft," J. B. Johnson.

On Thursday morning, among other things, there will be an address on "Features to be Considered in the Design of Oxy-Acetylene Welding Equipment," by A. J. Fausek.

A theater party has been arranged for Thursday evening, and the annual banquet will be held on Friday evening.

A GREAT LOSS

The American Welding Society, the welding industry and the General Electric Company suffered a great loss in the recent Pennsylvania wreck. Returning on a sleeper from Washington, where they had been attending an Inter-Works welding meeting of the General Electric Company, Rollin D. Reed, J. C. Horstman, Mark A. Atuesta and Arthur W. Gross were killed when their train was hit by a fast St. Louis flyer.

ROLLIN D. REED

Thomas A. Wry, chairman of the Boston Section of the American Welding Society, and D. H. Deyoe, formerly secretary of the Northern New York Section, who were also in the wreck, escaped with injuries.

Mark A. Atuesta, a member of the Manufacturing General Department, Schenectady, where he was attached to the staff of H. F. T. Erben, assistant vice-president, was born May 10, 1877, at Bogota, Colombia. He entered the employ of the General Electric Company in 1894 as a member of the Testing Department, Schenectady Works. After several years on test, during which time also he was engaged in outside construction work

tee of the society. These authors

The Friday morning session was

for the company, he became foreman in the testing department, a position which brought him in touch with the men now in the district and local offices, who were then on test there. In 1910 he left the testing department to enter the office of the technical superintendent of the Schenectady Works, and in 1916 became a member of the industrial heating department of the General Electric Company. In 1924 he was appointed to the position he held at the time of his death. He leaves a wife and daughter.

Rollin D. Reed, who had charge of the sale of arc welding equipment, Industrial Department, General Electric Company, Schenectady, was born in New York State in 1882 and was graduated from Union College in 1907. He joined the General Electric organization in 1902, left a year later, and returned in 1907 as a member of the testing department. After completing his work in the testing department, he spent about a year in the induction motor engineering department and two years in the production department. In March, 1919, he was transferred to what was then the supply department, and in January, 1916, became a member of what is now the industrial department. He had had charge of the sale of electrical arc welding equipment since 1919. He is survived by his wife and three daughters, and by his father, a sister and a brother.

JOHN C. HORSTMAN

Mr. Reed was identified with the Society from the beginning. He helped to organize the Northern New York Section and in the early stages was its secretary. He took keen interest in the work of the Society and in its research department, the American Bureau of Welding. He has to his credit a 100 per cent attendance at the Fall and Annual Meetings of the Society.

Arthur W. Gross, in charge of the factory suggestion system of the various plants of the company, with headquarters at Schenectady, was born at Erie, Pa., in 1893. He attended the Bliss Electrical School, afterward entering the employ of the Burke Electric Company at Erie. He entered the service of the General Electric Company as a draftsman at Schenectady in 1913, and two years later became a member of the publicity department as a technical writer. In 1923 he was transferred to the office of J. A. Smith, general superintendent of the Schenectady Works, where he was engaged in plant efficiency work. In 1924 he was assigned to the staff of Assistant Vice-President Erben, where he had charge of the factory suggestion system. He is survived by his wife and his father, the latter residing at Erie.

John C. Horstman was in charge of the application of electric welding to manufacturing processes in the Schenectady Works, and a member of the staff of Manager C. E. Eveleth. He was born at Schenectady in 1876 and entered the employ of the General Electric Company in August, 1892, at the Schenectady Works, where he took up die and tool work. Five years later he engaged in drafting work at the Lynn and the Schenectady plants. In 1902 he entered the D-C engineering department, and in 1907 joined the testing department, returning, the following year, to D-C engineering. Since 1913 he had been following the line of work in which he was engaged at the time of his death. Besides his wife, he leaves a sister and two brothers.

Mr. Horstman was also a member of the Society and was very active in the work of the Electric Arc Welding Committee. He assisted in the conduct of a very large series of tests for the Welding Committee during its connection with the Emergency Fleet Corporation.

WELDING ON BOILERS

By S. W. Miller

In view of the ever-widening applications of fusion welding throughout industry and the probability that repairs to boilers made in this way will be proposed from time to time, it is well that those responsible for the results should bear several points in mind. For simplicity, these are listed briefly below:

1. Most boilers are insured.
2. Many boiler insurance policies are so worded that if repairs are made without the authority of the company carrying the insurance, the policy becomes void.
3. There are Federal, State and municipal regulations governing this work, as well as those issued by the insurance companies.
4. Only competent welders, used to boiler work, should be allowed to do the welding.

Therefore, the following precautions should be observed by the owner or his representative:

1. Examine the part of the boiler to be welded in company with the insurance company inspector, and get his approval before doing any welding.
2. Be present at the test after welding with the inspector.
3. If possible, get the inspector to sign a statement that the work has been properly done and that it has passed the test successfully.
4. If the boiler is not insured, and comes under Federal, State or municipal supervision, carry out the above program in company with the proper authority.

If the boiler is neither insured nor under supervision of some constituted authority, ample precautions should be taken by the welder and the owner to protect themselves against possible future trouble. They should make a sketch of the location and size of the repair, with a clear statement of what was found wrong and how the repair was made. They should always make a hydrostatic hammer test of the finished job, using a pressure of 1½ times the working boiler pressure, in the presence of witnesses, and get their signature to a statement of the facts. These papers should be carefully filed away. In such a case, no welding should be done which is not permitted by law or by good practice.

In case of marine work, the welder should pass the regular examination of the Federal Steamboat Inspection Service.

In all cases, the welder should make friends of the insurance and other inspectors by refusing to do work unless authorized by them, by being conservative in what work he recommends, and by doing nothing except a first-class job.

EXHIBITS

Exhibits in connection with society and association meetings are not novel features. With many organizations they form one of the main attractions at convention meetings as they provide an opportunity for prospective users and purchasers to become familiar with the latest devices and developments in their particular field. It also allows the manufacturer to make direct contact with prospective users of his equipment, apparatus, materials and systems. Moreover, it has an educational value which is exceedingly important.

The American Welding Society made an initial attempt in combining an exhibit with its fall meeting in Boston in October. A list of exhibitors is given below:

The Iron Age Publishing Co., John A. Roeblings Sons Co. of N. Y., Metal & Thermit Corporation, Thomson Electric Welding Co., Torchweld Equipment Co., American Brass Co., General Welding & Equipment Co., General Electric Co., P. F. McDonald & Co., Air Reduction Sales Co., Acme Electric Welder Co., Westinghouse Electric & Mfg. Co., Burke Electric Co., Morris, Wheeler Co., Nicholas I. Mosher, Electric Arc Cutting & Welding Co., Purox Co., Una Welding & Bonding Co., Carbic Mfg. Co., The Alexander Milburn Co., New England Compressed Gas Co., American Electric Fusion Co., Ideal Face Shield Co., Page Steel & Wire Co., Lincoln Electric Co.

It is a source of satisfaction to know that this first attempt was a huge success. Aside from the fact that over 3000 prospective users witnessed these exhibits and therefore the objective of holding such an exhibit was fulfilled, there was received by the welding industry returns which are of far greater importance and will be far-reaching in the future, namely, the education afforded to the technical students of Massachusetts Institute of Technology and Lowell Institute. A unique feature of these exhibits was that nearly all of them were in actual operation.

SECTION ACTIVITIES

New York

The first meeting of the New York Section was held on Oct. 5. S. W. Miller presented a paper on "Testing the Completed Weld." This brought forth considerable discussion. Cider, smokes and entertainment in the form of a comedy motion picture were also featured.

The second meeting was held on Nov. 13 in the Engineering Societies Building. G. O. Carter, consulting engineer, Linde Air Products Co., presented a paper on "Shop and Employment Tests for Qualified Welders." The discussion brought forth that it was universally agreed that with proper selection of materials, design, technique, apparatus, supervision and with good operators, uniform results could be obtained in welding. The human element could be eliminated to a considerable extent by employing qualified welders, whose skill for doing a particular job could be checked from time to time. The other paper of the evening was presented by N. T. Chute, district manager, Lincoln Electric Co., Cleveland Ohio. This paper was prepared by H. P. Egan of the same company and described in detail the erection by welding of a large two-story garage in Alliance, Ohio. Lantern slides were shown in connection with both papers.

Western New York

The following is a list of the scheduled meetings of the Western New York Section: Oct. 27, 1925, Allan Mfg. & Welding Co. Paper and actual demonstration of arc welding of cast iron automobile cylinder blocks; Nov. 18, 1925, A. G. Bissell, Westinghouse Electric & Mfg. Co.; December, 1925, "Problems Met in Welding," C. E. Burkhart, Struthers-Wells Co.; January, 1926, "Phenomenon of Electric Arc," R. E. Kinkaid. Lincoln Electric Co.; February, 1926, F. E. Rogers, Air Reduction Sales Co.; March, 1926, "Testing a Completed Weld," S. W. Miller, Union Carbide and Carbon Research Laboratory; April, 1926, A. S. Kinsey, Air Reduction Sales Co.; May, 1926, Burke Electric Co.

Cleveland

The first meeting of the Cleveland Section was held on Oct. 20. R. H. Storm of the Morgan Engineering Co. presented a paper on "All Welded Buildings." This paper was accompanied by moving pictures of the actual work. There were 100 people present, among them many architects and engineers who showed great interest in the discussion that followed.

The November meeting will be arranged as a joint meeting with the Civil Engineering Society of Cleveland. A. G. Bissell will present his paper on "Arc Welding in the Building Industry."

Chicago

The October meeting of the Chicago Section was held on the second in the rooms of the Western Society of Engineers. S. W. Miller of the Union Carbide and Carbon Research Laboratories, presented a paper on "What Occurs in the Oxy-Acetylene Cutting of Steel." The discussion which followed showed that there was a keen interest in the subject and special attention was given to procedure control in oxy-acetylene cutting of specific jobs. The November meeting was held on the 6th, at which time A. G. Bissell of the Westinghouse Electric & Mfg. Co. presented a paper on the "Adaptability of Arc Welding to Structural Steel Fabrication." The paper was accompanied by fifteen lantern slides and aroused considerable discussion.

Los Angeles

The fourth reorganization meeting of the Los Ange'es Section was held on Sept. 24. The following officers were elected: Chairman, L. G. Hicks, Standard Oil Co.; vice-chairman, F. S. Hatfield, Gay Engineering Co.; secretary and treasurer, L. R. Ardouin, U. S. Steel Products Co.; executive committee, Barton Brown, Prof. R. L. Daugherty, Oscar Lund, A. Max Lee; by-laws committee, J. Max Lee, D. L. Abshire, Barton Brown; meetings and papers committee, C. Mott, E. J. Cipperly, R. E. Gracey; membership committee, F. S. Hatfield, C. A. Vicklund, T. McMahon.

Detroit

The October meeting of the Detroit Section was held on Oct. 1. H. B. Fuller of the Detroit Testing Laboratory presented a paper covering his experiences in testing welds. Some useful information was brought out regarding the make-up of different classes of metals by showing photomicrographs of welds taken in different stages.

Pittsburgh

The October meeting was held on the second, at which Prof. A. S. Kinsey presented an address of "Impor-

tant Things to Know About Fusion Welding." The November meeting will be held on the 13th, at which time A. M. Candy of the Westinghouse Electric & Mfg. Co., will present a paper on "Rivet Cutting and Reclaiming Steel Freight Cars with the Electric Arc."

San Francisco

A joint meeting was held on Oct. 8 at the Pacific Railway Club. Several interesting talks by railway men on the uses of welding in different phases of railway work were given. The November meeting of the section will be held at the Engineers Club on Nov. 12. S. W. Miller will present an address on welding, covering a discussion of the boiler code rules on unfired pressure vessels, the design of materials for welding and the strength of welded joints.

EMPLOYMENT SERVICE BULLETIN

Opportunities.—The Society is glad to learn of desirable opportunities from responsible sources, announcements of which will be published without charge in the BULLETIN.

Services Available.—Under this heading brief announcements (not more than seventy-five words in length) will be published without charge to members. Announcements will not be repeated except upon request received after an interval of three months; during this period, names and records will remain in the office reference files.

Note.—Copy for publication in the BULLETIN should reach the Society's Office not later than the thirtieth of the month if publication in the following issue is desired. *ALL REPLIES should be Addressed to the number Indicated in Each Case and Mailed to Society Headquarters.*

Services Available

A-39. Acetylene welder desires position. Have had six years' experience in welding and brazing of all metals. Have been connected with the Todd Engineering Co., The Westchester and Lighting Co., and the National Transit Pump and Machine Co. Can give references.

A-40. Welder desires position. Am an expert in oxy-acetylene welding and cutting and can also do thermit welding. Have had seven years' experience in railroad repair shops, one year as pipe line welder, one year as general cast iron welder, one year as general sawmill welder, one year as repair man and brazing of all methods. Understand preheating. Prefer a job in some northern State around Chicago. Can run a shop as welder foreman in either railroad or contract shop. Can inspect welders. Capable of being service demonstrator and salesman.

If you need welding talent or are looking for a position write to the American Welding Society.

The Industrial Picture Through the Focus of Research*

By MAURICE HOLLAND†

I have used the word "Industrial Picture" advisedly since an old Chinese proverb says "One Picture is worth ten thousand words." I assume that the present day Industrial Picture is so impressed upon your minds that I but need to direct your attention to the lens through which we will view it in perspective. In order that the focus of research may not be mistaken for a magnifying glass, and in order that we who are intimately connected with research activities may maintain an equilibrium in its relative importance compared to industry as a whole, I am going to draw the analogy that James J. Hill once used when confronted with a gentleman who took credit for the development of the Northwest. He said "in a large power plant one time there was a fly on the ceiling who was contemplating with considerable awe the ponderous fly wheel which was the primary motivating force of this unit. Presently the fly, descending from his elevation to the surface of the wheel, was surprised by the rotary motion of the huge mass simultaneously with his arrival. He returned to his place on the ceiling and observing the ever increasing speed of the wheel he said, 'See what I have done.'" Perhaps this is why this piece of mechanism is known as a fly wheel.

The relative importance of research to industry in various countries is indicated by the fact that in England the British Government has a subsidy plan by which an appropriation of approximately five million dollars was made some years ago to encourage the establishment of cooperative research associations in various industries. At present there are twenty-six active research associations operating under this plan. The industries and the Government participate equally in that the industry is required to subscribe a pound for each pound subscribed by the Government. In France the Government allows industrial concerns to deduct from their income tax a percentage of the funds appropriated for research. A bill has been passed in the Chamber of Deputies which provides for a tax of five centimes on each 100 francs paid in salaries by all industrial concerns. It is estimated that the tax would raise about $700,000 annually for scientific research laboratories. In Germany industrial research amounts almost to a creed.

In this country, while there is no governmental department directly charged with the specific duty of encouraging research, the National Research Council has been organized to perform this function. Without being an integral part of the Government, the

*Presented at Fall Meeting of A. W. S., Boston, October, 1925.

†Director of Research, Div. of Eng. and Industrial Research, National Research Council.

Research Council operates under the Congressional Charter of the Academy of Sciences and by an executive order of the President is assured of the full cooperation of our Government scientific and technical bureaus.

We are spending approximately one hundred million dollars a year in the United States for research. The Government with its many scientific and technical bureaus, and research agencies attached to practially every department, is spending approximately one-third of this amount; while industry is matching dollars spent for research two to one for the government expenditures. There are nearly 600 industrial research laboratories in the United States excluding the Government bureaus and research agencies connected with the universities and technical colleges. The trade associations alone are spending approximately twelve millions a year for research. This, then, is a thumb-nail sketch of the volume of industrial research activities in this country.

I am now immediately concerned with trying to, in some measure, establish in your minds the relative place of industrial research in the whole industrial picture compared to, say, advertising, statistics, publicity, traffic analyses, and other recognized business aids with which you are doubtless familiar.

One hundred years ago industrial supremacy, either by an industry or by an individual concern, was largely a matter of the control of raw materials. Within the last twenty-five years this new factor, industrial research, has considerably changed the state of affairs. That industrial supremacy is in large measure dependent upon research organization for its development, growth and earning capacity is indicated by the recently published statistics of the income tax paid by the twenty-five largest industrial concerns in America. If you will scrutinize this list you will at once be impressed with the fact that among the first ten are names that are synonymous for large and completely organized research departments. These industrial concerns in order are Ford Motor, American Telephone and Telegraph, U. S. Steel, General Electric, General Motors, Standard Oil, New York Central, Consolidated Gas, Union Pacific and R. J. Reynold Tobacco Companies. Eight of the first ten count as an essential part of their plants research units of international repute. The total income tax paid by these ten companies is approximately $75,000,000, three-quarters of the aggregate expenditures for research for the whole country.

Industrial research not only affords technical superiority in competition between industries, or provides an advantage to the concerns within an industry which is competing with its fellows, but it is an even more dominating force in the present day industrial structure, since it creates industries and even destroys them. Destroys, in that it revolutionizes the present processes, invents new ones, and therefore is the primary cause for the creation of a new industry or the specialized sub-division of the same industry.

I need but to mention the case of the introduction of methanol, the German process for the production of wood alcohol, and the tremendous impression that it made in this country, the fears that it aroused that our wood alcohol industry would be entirely eliminated because of the technical superiority of our competitors from across the sea. Here in New England there has been considerable political agitation for the erection of a high tariff wall to protect the textile industry. I can give you my assurance, as I have given it to a number of executives in the textile industry and their associations, that it is not possible to erect a tariff wall high enough to keep out the productions of research in that industry which have been developed by technical superiority in England and in Germany. I personally observed in textile research laboratories in these countries, during investigations abroad last summer, developments which will become commercial realities within the next year or two, that should be the most potent force in dissipating the idea among the industrial executives of the present security of their position. Similarly, in a number of other industries in which I had an opportunity to make observations in several countries in Europe, they have been so busy improving the basic technology of their industry that, as yet, they have given no appreciable amount of time and effort to the commercial exploitation. When the latter phase of this present work becomes apparent, we will be called upon to face a competition from abroad which will be considerably more effective than any which we have encountered in the past.

There are five factors which govern, to a large extent, the relative growth and development of research within an industry. The first is the inherent technical nature of that industry. Obviously such industries as the chemical, electrical, automotive and others of this general character, are virtually born in the research laboratory. The seed of research is deeply rooted in the foundation of the industry itself. The second factor is the technical character of the personnel of an industry. Some industries which come to mind have relatively small numbers of technically trained personnel considering the whole number of employees. A third factor is the character of production of an industry. A fourth is its position in foreign trade. As an example of the last, before the war there was practically no optical glass produced in this country. When we were cut off from the foreign source of supply, it was essential for us to produce optical glass in this country, consequently the glass industry, with the assistance of the Government research bureaus, notably the Bureau of Standards, under the pressure of an emergency undertook the development of an optical glass in this country which was the equal, if not the superior, of that produced abroad. Post-war developments have largely been responsible for the creation of a new industry in this field in the United States.

The fifth factor is the rate of development and growth of the

industry itself. It may seem paradoxical, but it is nevertheless true, that the older industries have been the last to adopt research. The electrical industry, which within the last forty years has come to take the position of third in relative size of our industries, has done so largely because of the fact that it encompasses at least three of these factors which I have mentioned above. The motor car industry, which is reckoned as the first in size in the Department of Commerce Census of Manufacturers, has taken advantage to a large extent of the possibilities of research organization. I need but to mention the General Motors Research Corporation, which is the centralized research laboratory for the General Motors group; the very considerable research organization of the Packard Motor Company, the completely equipped automotive research laboratory attached to the Studebaker and Dodge plants, and last, in point of time but far from least, the recently established research laboratory of the Ford Motor Company, which is a model in construction, design and equipment of ultra-modern laboratory serving the automotive industry.

This sketchy review of some of the salient features which govern the relative growth and development of research in specific industries and to industry as a whole, has, I hope, oriented our trend of thought toward the basic consideration of the relation of industry to research which I hope to leave with you.

If you were to look around you and select ten of the tools of modern industry, such as, for example, the textile looms, electric motor, the turbo generator, the automatic screw machine, the motor truck, and compare their relative earning capacity as units in an industry, you would have the yard-stick by which I am going to measure the real fundamental principle, the relative importance of research in the development and growth of an industry. This measure is not primarily one of production capacity measured in dollars, but rather a measure in time of a cycle of development. In order that the thought which I am attempting to present may not become too complex and abstract, I will illustrate the generality with concrete example. The present electrical industry traced to its ultimate source may be said to have its foundation in the classic experiment of Faraday in pure science research in which he discovered the principle of the modern electric generator, namely, the cutting of electro-magnetic lines of force. This experiment may be designated as the discovery of a principle in pure science research. The next step in the cycle is applied science or industrial research, in which the basic data resulting from fundamental research is applied to the objective of solving a technical problem which is arresting industrial development. The next phase is the creation of an invention or perfecting device which applies this industrial research as a tool in the service of industry. The next step is the standardization of the experimental device into a production tool of industry, and the final step is mass production. Now, if we go back to our ten modern tools

of industry and compare the time cycle, that is, the period which has been occupied in the complete development from the discovery in pure science through the various stages enumerated above, to the production period in industry, you will find that in several instances this period may have taken from 50 to 200 years.

In its larger aspects, a statement of the broad purposes of the National Research Council is to stand as sponsor at the marriage of science and industry. To employ its resources in speeding up this cycle and to reduce to a minimum the time lag from the discovery in pure science to the mass production application in industry. If we can so much as reduce this period by 25 per cent, we have gone directly to the vitals of the engines of industrial progress and inserted a gear which will speed up the rate of production, the earning capacity, and the industrial progress of a nation as a whole as no other service could possibly accomplish.

In concluding, I want to leave a complimentary thought in your minds, and that is the importance of the period in the development and growth of an industry at which the entrance of research as a factor may effect its subsequent rate of progress. For example, the Division of Engineering and Industrial Research has placed its services at the disposal of the moving picture industry in an effort to establish a research organization in that industry. One of the high officials in the industry, upon being approached, made the observation that the industry was so young that he doubted whether or not the time had come for the introduction of research. Incidentally, the industry is only nineteen years old. Without much difficulty it was demonstrated that the introduction of research at this early period in the industry's development would mean first, that it would not have to break down old prejudices and traditions; it would not be necessary to combat technology and practical experience which had been handed down for generations, but that the greatest advantage would accrue in the next twenty-five years of development by the introduction of research while the processes were in the state of flux and adaptable to improvement based upon scientific principles. One other example occurs to me of an even younger industry. I refer to commercial air transport, perhaps the baby of all industries in this country at the moment. This industry is but six years old. The Division of Engineering and Industrial Research is represented on the Advisory Council of the Daniel Guggenheim School of Aeronautics and Research. Through the coordination of effort of these two agencies, an influence may be brought to bear upon the introduction of industrial research and the application of scientific discoveries in aeronautical engineering, in which the period which I referred to above will reduce the time lag from 50 to 200 years to perhaps two or three years.

The results of an early introduction of research and its bearing on the development of an industry is, I am sure, apparent. I do not, however, need to go as far afield as the moving picture or com-

mercial air transport industries to carry this point across to you, since I can more effectively bring it home by simply mentioning the considerable influence which the American Bureau of Welding, and particularly its research accomplishments, has had upon your own industry.

As I understand it, but a few years ago welding was largely dependent on the skill of the operator and the technic of practical methods. Today, however, its processes are formulated from scientific data based upon fundamental research.

There are, however, two gentlemen who follow me, who, I am sure, can much more adequately interpret for you the generalities which I have touched upon in the whole research picture and interpret its meaning for your industry and in your own language.

Testing the Finished Weld*

By S. W. MILLER†

It is obviously necessary to destroy any structure if it is desired to know its ultimate resistance. Of course, it is impossible to do this in each case or instance. It has therefore become sound engineering practice to test to destruction one or more samples that are like the completed structure, and to use the results obtained as a basis for design, on the assumption that if other samples are made in a similar way they will be of a strength sufficiently close for all practical purposes to the one destroyed.

It has been found by experience that the designer must use what he calls a "Factor of safety" to allow for irregularities of various kinds in the construction, such as non-uniformity of material, imperfections in workmanship, and the impossibility of determining the exact stress to which the piece is subjected in service. For example, the ultimate strength of a steel plate may be at one end 60,000 pounds per square inch, while at the other end it may be 70,000 pounds or more, as this is a practical condition that cannot be overcome if we wish to keep within reasonable cost. With regard to workmanship, it is not possible to secure exact uniformity and the highest quality in every piece that is made, no matter what manufacturing processes are considered. A good illustration of unknown service stresses are those in the case of railroad locomotives and cars. It is evidently impossible to decide before hand on the exact stresses produced in the various parts of such equipment running at high speeds over tracks that are more or less rough. Of course, experience shows us when the part is too weak, and we overcome the difficulty by increasing its strength in some suitable way, either by making it heavier or by using materials of superior quality.

In no case, however, is it possible to utilize the full capacity of the material in the structure in our strength calculations. Evi-

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dently if the material was stressed this much, it would break, so it is customary to load the structure to a point less than this amount, quite frequently using a factor of safety of 5. In ordinary boiler construction, this may be said to be the standard factor of safety, while in aeroplane work, where the maximum lightness should be obtained, it is customary to use a much lower factor of safety, say of the order of 2. It is also evident that we must not allow the material to be stressed in service up to the point at which it is permanently deformed or distorted, because if this is done, the dimensions of the piece will change and cause difficulty. On the other hand, in the case of parts that have to stand severe shocks and unknown stress, for example in the case of rolling mill engines and rolls, the design factor of safety is much higher. Of course, the actual factor of safety may not be any greater than 2 or 3 under service conditions, but because of the impossibility of determining the actual stresses, the designer uses his best judgment as to what they are and then makes his calculations, using a large margin of strength.

It is quite reasonable to devise various methods of test to suit the various conditions in service. For instance, a chain is designed to work in tension only, that is, to support a load. Therefore, the only test that it is fair to apply to a chain is a tension test. There are very few structures, however, that are as simple in the stresses which they undergo as is a chain. Another comparatively simple case is a tank or pipe subjected to internal pressure. Even in such cases as these there may be other stresses, as from shock due to a suddenly applied load in the case of a chain, or to an explosion inside the pipe or tank. More complicated structures such as roof trusses require consideration in the design of loading caused by wind, the weight of snow and other irregular loads and many tests have been made to find the effect of these and other loads on all kinds of structures. One common form of test in cases where severe shock is encountered is that used in the case of railroad car axles, commonly called the drop test. In this, a weight is allowed to fall from varying heights on a properly supported axle and the amount of permanent deflection under definite conditions of application of the weight are taken as a measure of the resistance of the axle.

It is therefore evident that the testing of any structure, including those made by welding, should be done in a way that will show its resistance to stresses that we know exist in service. We may, of course, with advantage, in order to learn more about the resisting power under different conditions, make a series of tests that will show up all the various properties of a structure. In the case of welded pieces, we might make tests of the ultimate strength in tension, bending, compression, shock, alternating stress, torsion, and the various other ways outlined in Bulletin No. 1 of the American Welding Society. Such tests would probably be made on small specimens, not on full sized structures, it being considered good

engineering practice to do this. If the figures so determined are used in the design of a structure, that is, tested to destruction, and if the structure fails at a load approximately that for which it is designed, it is fair to consider that the design figures are safe, that the method of design is correct, that the workmanship has been reasonably good, and that we can have confidence in other structures similarly made.

In many cases, and this is as true of welded pieces as of those not welded, the question of strength does not enter seriously. It may only be desirable to have a smooth finish, and the weld would under such conditions, only need to be free from porosity or other imperfections, and to have a sufficient amount of metal added to allow for proper grinding or other machining. The testing of such a weld would be by visual inspection and this can be done rapidly. In other cases, for instance that of an open tank, the appearance of the weld has little to do with the results, but it must be tight. This test is easily made by filling the vessel with liquid and making a visual inspection for leaks. Some times it is necessary to match the color of the weld with that of the pieces being welded. This is particularly true of brasses and bronzes. In such cases the problem is more complicated, because while the matching may be perfect after the weld is smoothed down, it may discolor in service to a different extent from the base metal. Some ingenuity and research may be needed to produce an alloy that will meet the requirements and at the same time have good welding qualities.

Resistance to corrosion is frequently different in the weld metal to what it is in the base metal. This is an exceedingly complicated matter and usually the best results can only be obtained by service tests, although much may be learned by subjecting the welded pieces to short time tests under control conditions in the laboratory.

The test that is of the most value in the case of welds is that in tension, by which the ultimate strength, that is, the breaking load per square inch of base metal, the yield point or elastic limit, which are to all practical intents and purposes the same although technically somewhat different, and the percentage of elongation and reduction of area, are determined. In ordinary metallic materials, these tests are made on pieces that are practically homogeneous. A welded piece is not homogeneous and the physical properties of the weld metal and of the base metal are never the same. The qualities of the two metals approximate each other more closely in the case of castings than where forgings are welded. For these reasons tensile tests on welded specimens should be properly made, interpreted, and applied.

My belief is that, where the matter of strength is vital, the weld should be so designed and made as to be greater in strength by a considerable margin than is the base metal. As an illustration of this, many of the tanks, the results of whose tests are described in bulletin No. 5 of the American Welding Society, were made with low tensile strength plate, and with the welds so reinforced that the

rupture occurred outside of the weld. The basis of the recommendations of the Committee of the American Welding Society in that bulletin for double V welds was based on the fiber stress at rupture (which was in all cases except one at least equal to the tensile strength of the plate, about 50,000 lb.), with a factor of safety of 5, and with an allowance of 20 per cent for the various irregularities that might occur in practice, giving a design figure of 8000 lb., or based on the ultimate strength, a factor of safety of 6 1/3. It is, however, clear that with welding wires of higher strength, the design fiber stress might be increased and higher tensile strength plate used, although the factor of safety would remain the same. It is very interesting to notice in these tests that the tensile strengths of the welded specimens were very close to the actual strengths of the tanks and that they broke outside the weld. This shows that tensile tests of welded specimens may be relied on to give satisfactory and safe figures for the design of welded tanks.

Of course, in these tests the welds were reinforced so that the conditions would be the same as in practice, but it is often, and indeed usually, better to make the welds of the same section as the base metal, either by machining or grinding. Such test pieces will determine the strength of the metal in the weld if the weld ruptures, and is a better indication of its quality both as regards continuity of the metal, general structure, and strength, than the reinforced weld when the rupture occurs outside of the weld. In the latter case, nothing is known except that the reinforced weld is stronger than the base metal, which is, after all, not complete information.

A very interesting and instructive method of test has been developed in the last few years that is applicable to any form of structure and that is largely used in the case of bridges, columns, and other similar constructions. It consists in measuring the strain or distortion in any part of the structure by means of very accurate gages. Its principle may be explained by considering a tensile test piece. In this case, if a piece one square inch in section has a load applied to it in the testing machine, the increase in length due to that load can be easily measured very accurately. As the load increases the length also increases. These increases in length and the corresponding loads are plotted against each other on cross section paper, and the resultant curve shows what we want to know. Such tests are called stress strain tests, because they determine the relation between stress and strain.

Now in the case of a bridge, it is not known exactly what load exists in the different joints, but if we measure the distortion or strain at any point accurately, we can determine the load that causes that strain, because the coefficient of elasticity is practically the same for all steels, regardless of their chemical composition or character. This coefficient is sometimes called Young's modulus, and has a value of 29,000,000. Its meaning is that if any steel were perfectly elastic under all loads, a strain of 29,000,000 pounds per square inch would double its length.

The method has been used for years in the examination of tensile test pieces, but its application to large structures is more recent. We have applied it to welded tanks and a welded kiln body. The tests on the kiln shell are very interesting, as it is the first all welded shell that has been made. It is 125 feet long, 8 feet in diameter, made of $\frac{5}{8}$ in. plate, and is used for burning lime. It has been in service for two years without any evidence of distortion or other injury.

The stress strain tests made on this kiln showed that the stress per square inch of plate section was 3000 pounds. This was at a girth seam and under normal operating conditions. At times conditions are abnormal and then the maximum stress is 4700 pounds per square inch.

A riveted kiln was also tested at the same time and the apparent stress across the riveted joint was 6000 pounds per square inch. This is possibly due to a slight movement in the riveted joint that could occur if the rivets did not exactly fill the holes.

These tests show the advantage of a welded joint over a riveted one, as the weld is perfectly rigid, and even if it is assumed that there is no greater stress on the riveted joint than on the welded one, there must be some movement of the former. If, on the other hand, the 6000 pounds is a real stress instead of an apparent one, welding again shows its superiority as it distributes the stress uniformly through the plate.

The test further showed that with a welded joint the thickness of the shell can be decreased to at least $\frac{1}{2}$ in. without increasing the stress beyond a safe point. With this thickness, the maximum stress under abnormal conditions would be 5600 pounds per square inch, which certainly is not at all serious on a double V weld, which was the type of the girth seam.

This method of test, giving as it does the actual stress, enables the design to be made much more economically, both in weight of material and cost of welding, as the weight of the shell would be about eight tons less with $\frac{1}{2}$ in. plate, and as the cost of welding $\frac{1}{2}$ in. plate is much less than that of $\frac{5}{8}$ in. plate.

In the case of a tank, the calculation of its strength is much simpler than in the case of a kiln, but even here much information was obtained by the use of the strain gage. The principal information is that, properly designed in accordance with present well known methods, there is no stress beyond the yield point in any part of the tank at the working pressure, and that a hydrostatic test of three times the working pressure can be safely applied.

What has been said shows the necessity of using different methods of test, depending on the object desired, and this paper has been written with the idea of pointing out that in different cases different methods will have to be devised for testing welded products.

Discussion Paper on "Gas Welding of Power Plant Piping"*

BY A. W. MOULDER

The afternoon session was called to order by President A. G. Oehler. An address of welcome was delivered by Mayor Quinn of Cambridge. President Oehler presented Prof. Alfred S. Kinsey, of the Stevens Institute of Technology, Hoboken, N. J., who presided.

The paper "Gas Welding of Power Plant Piping," as printed in the October issue of Journal of the American Welding Society, was summarized by the author, A. W. Moulder, Chief Engineer of the Grinnell Co.

CHAIRMAN KINSEY.—You have heard the digest of the paper and some of you have copies of the paper so that you can become quite familiar with the rest of the article. This is your opportunity now to ask the author questions, and to bring up anything that you have which is appropriate and helpful to us along this same line.

MR. GLENN O. CARTER (*Consulting Engineer, the Linde Air Products Company, New York*).—Mr. Moulder says the welding engineer is the man who has the responsibility for the layout of the piping system, and I note that among some of the interests in the game the companies are beginning to go to the drafting board and lay out the work for welding.

The General Electric has done a good deal in that direction in their general construction work. We have found that our general welding processes have been limited to the last year or so in making this change, and now more attention is being paid to the drafting board end of the work.

The consulting engineer is the man who will lay out the work. In our own organization we are having a check made on all construction work through the year where we can use welding, and I think we have used all the processes except the thermit process. I do not believe that half of the welding has been done in our own concern that should have been done in the last five years. I do not believe there is a man here that can say there has been all the welding done that should have been done. People are ready to use welding whenever those of us who are on the technical end of it are willing to call attention to it and point out the advantages.

A steam line that has bare flanges loses twice as much heat as does a line that is absolutely covered from the air. Very few steam lines have their flanges covered after they have been in operation a while. The flanges loosen up, the steam gets under the insulation and they take the insulation off in order to tighten up the flanges. There is a very distinct power saving which can be made.

*Paper printed in October, 1925, Journal of the A. W. S.

Installations like the Commonwealth Edison installation in Baltimore, whenever they shut down the line make welds at the flanges in order to increase the efficiency of the installation.

Another point I want to make is the reliability of the welding processes when done by competent welders and under proper supervision. Ten days ago I had a chance to talk with Noah Wagner, who is well known to you and who has given us several papers in the class with Mr. Moulder's paper. Oil lines carrying from 600 to 750 pounds pressure are less than standard weight 8-inch pipe. There are over 1000 miles of welded insulation, and they have never had a cent of damages or experienced a circumferential weld break. I believe that Noah Wagner was a boiler maker and learned welding, or rather learned how to test welding. No man goes into his employ without making test pieces and showing that he is a competent welder before he starts. There are plenty of big rewards to the engineer who has shown the real strength of character to use welding for his clients and they get a big return.

MR. L. FAIRBANKS (*Quincy Market Cold Storage & Warehouse Co.*)—The piping system of our plant is all welded construction. It is more a question of proper design and proper attention to the requirements of welding than it is perhaps of any other thing. I believe that the welding of piping in the power plant is coming very rapidly, and the principal thing that we need to do is to instill confidence in the man who is responsible for the work.

Unquestionably the comparatively few cases of defective welding has had a very bad effect on the industry as a whole. Much of that I think has been eliminated by modern processes and by supervision and a better understanding of the requirements. In our own work they are using it practically in all cases where it is possible to weld with safety. There are positions in construction, in power plant piping, where it is a very difficult thing for a man to weld satisfactorily. That is, much of the overhead work where long lines are required, which need welding in position, are taken care of with great difficulty.

Most of our own steam lines, underground lines and practically all of our steam lines under the harbor are all welded. Formerly we used a number of different types of joints, and with the normal contraction and expansion it is a foregone conclusion that some of these joints will leak sooner or later. But having taken out most of that work and substituting welded joints, we have no trouble whatever.

We had to do considerable pioneer work, however, in working out methods by means of which successful welding could be done. That is, to have the conditions and piping such that a man could get at it readily, and sometimes that is very difficult. In so far as much of the so-called disconnecting work is concerned, we found that each man could cut out a length of pipe, rather than break the joint, and we now use a torch so as to cut the pipe off and make

a new joint, which is done quicker than to take down the pipes with high pressure joints. Our experience in that direction has been very favorable.

MR. FRED E. ROGERS (*Air Reduction Sales Co.*)—I can hardly be quoted as an authority on pipe welding, although I have been in contact with a number of jobs. What I would say would be to direct your attention to some of the advantages of welding pipe lines. The contour of the ground has to be taken into account, and possible provision made in the steel pipe. For example, where you are laying a heavy line 16 or 17-inch line, over territory such as we have in New Jersey, unless the trench is conformed to straight lines at heavy expense, the welder is confronted with the necessity of making other than square joints. That is, he has to conform the welds to the joints which have to be made. Considerable difficulty would be experienced in any other process, if, when the pipe is brought together at the bottom, it is opened up a half an inch at the top. Whereas, in welding it is a matter of cutting the parts to an approximation of the angle required, and then going ahead and welding. One has to see the practical advantages, perhaps, before he appreciates what it means. In going through towns where, to avoid disturbing water lines and so forth, they have taken the back streets and often struck rock and rough forms, and a great many bends are involved. Three-piece bends were made up right on the job with all sorts of angles. It might be less than a right angle or more than a right angle. The welder used two tools. The welding torch and the cutting torch is the master of the situation. With these tools he can practically meet any situation in the field or in the power plant. If it is a matter of making up bends, he cuts his commercial pipe to the angles required, puts them together and welds. If it is a case of running an outlet in the power plant, it is merely the matter of cutting a hole through the main pipe, inserting a nipple or outlet, and welding it in place.

I am thoroughly sold on the idea of pipe welding. I believe that in the future years the main piping in our principal cities at least will be specified to be welded. The architects are already falling into line. They realize what the advantages are, especially as is the case in New York City where the piping is to be concealed behind very heavy concrete construction, in a position where, if the piping goes wrong, it will involve very, very heavy expense to get at it. The architects have specified welded piping in the belief that that piping or those pipes, when put in there welded and properly tested, will be good for practically all time to come.

MR. JAMES W. OWENS (*Welding Aide, U. S. Navy, Norfolk, Va.*)—I think much is due to our piping friends for our advancement. In the Norfolk Navy Yard at first we found some difficulty in getting the work introduced, especially in our shipbuilding shop, but we happened to have at that time a progressive master plumber

who saw the possibility of welding in pipe lines. The result was that our welding shop there was organized under the master plumber.

We have been able to extend the pipe welding very considerably at that yard. We do not hesitate today practically to weld almost any pipe. Pipe flanges, at least the expanded flanges and screwed flanges and screwed couplings, are disappearing very rapidly, and the welded joints are taking the place of mechanical joints in ship construction.

Expansion joints made up in the form of an accordion have been made, tested and proved to be thoroughly satisfactory. Joints of that type save considerable space.

Mr. Rogers' point about the cutting torch and the welding torch being in the hands of the same operator, and the advantages of it, is a very important point in considering whether gas welding should be used on a job. The fact that both of those tools are in the hands of one operator, that he can cut and weld, is a very important point.

Design should be carefully considered. Today we are standardizing our various welded fittings. A contractor should go first to the designing department and not leave the fitting to the man or the men in the field. It should be worked out in the drafting room, so that the least amount of welding will be used, to reduce the cost of the job to the minimum. Sometimes we use too much weld metal, and sometimes use two welds where one would do.

I do not yet know of a failure of a welded pipe line. We have in the Norfolk Navy Yard miles of buildings, many of them located quite some distance apart, and practically all the steam mains, with pressure lines of 250 pounds pressure, are all connected together by welded joints, and some of them have stood up for more than 10 years. I am convinced that the use of welding in pipe line construction is increasing substantially, and that there will be a time soon when all mechanical joints will be welded.

STUART PLUMLEY (*Managing Editor, Acetylene Journal, Chicago.*)—I want to ask if Mr. Moulder has any figures on the relative cost of insulating pipe.

MR. A. W. MOULDER (*Grinnell Company*).—I have not any figures, but I would judge that if the flanges themselves were not insulated that the relative cost would be approximately the same. In any case there would be a slight advantage in the cost of the continuously welded line, but that advantage would not be great in case the flanges were not covered completely. Of course, everybody in the piping business understands that the covering of the flange on the pipe is the most expensive part of the covering, and would double the cost of covering on a high pressure or low pressure steam plant. However, in very few cases do they consider covering flanges except on high pressure lines where the heat loss is greatest. I brought out that same point that Mr. Carter brought out about the heat loss being equal on the flanges

to that on the bare pipe itself, and that is according to some record of engineers in superheated plants.

Mr. F. X. WELLS (*Fisher Body Corporation, Detroit*).—I would like to ask Mr. Moulder if it is possible to go over a line already installed of cast iron piping, and take out the flanges without taking the line down. We have a hot water heating system. All the nipples are welded, but most of the joints are screw joints, and a lot of them are cast iron flanges. All the leaks are caused by the screw fittings and not at the welded joints.

MR. MOULDER.—I think I know the job. Your line is put in with screwed couplings, screwed flanges, but there are no tees in the line, and only nipples welded into it. Where you have screwed couplings you can weld those and make them tight. Where there are screwed flanges, the only thing you can do would be to take out the flanges and put in couplings and weld them. To take off the flanges and weld would not do. You would have to put in a slip sleeve or screw sleeve.

On an ordinary screwed flange the pipe does not come clear through the flange. They are probably three-eighths of an inch short.

MR. G. O. CARTER.—You can just cut the flanges right off and put in a straight piece with two welds.

CHAIRMAN KINSEY.—Is there anyone who has kept some cost figures on welded joints?

MR. G. O. CARTER (*Linde Air Products Company, New York*).—Our figures show that the welding is cheaper, but we do not like to lay stress on that. We say that it is just as cheap as any other process, but we are laying stress on the quality. It is very pleasant here to listen to the remark that the welded joint has never broken or leaked. We lay the stress on that.

MR. WILLIAM SPRAGUE (*Secretary, American Bureau of Welding*).—I would like to ask Mr. Moulder if he has had any experience in welding pipes for high temperature.

MR. MOULDER.—In the latter part of the paper I tried to cover that. It is my experience that a joint properly made is thoroughly capable of taking care of the conditions of a superheated job or a superpower job, ranging from 350 pounds up. I could tell you of any number of installations with pressures up to that. In fact, they are being made every day. But the specifications of materials for these high pressure and high temperature jobs are in the hands of men who are bound to take into account their responsibility, and almost disregard the first cost, so that the "Sargol Joint," which I have shown a detail of, has become really a standard for very high pressure and high temperature work. That does not seem to be true in the oil fields, however. I know of some installations where they have very high pressure and high temperatures, such as we do not approach in steam work, and as I understand it, they have used oxy-acetylene welding with just a plain butt weld with very good success. In fact, we have welded

back as far as 1910 in this manner, and I have recited one case of an emergency, where we put in some welded fittings in place of some cast steel fittings that we could not get, and that was back in 1912, and they have been operating a line at 250 pounds pressure, 100 degrees superheat, I think, for all those years.

PROFESSOR C. A. ADAMS (*Harvard Engineering School*).—The part that the consulting engineer plays in the specifications for materials and methods in power plants and structural work was mentioned. One of the functions of this Society is education. One of the reasons why welding has not progressed more rapidly is due to the fact that those responsible for this matter are in many cases largely ignorant of the possibilities of welding.

It seems to me that, inasmuch as welding, all told, constitutes one of the most useful if not the most useful tool in all the processes of industry, that it is a part of the job of every educational institution to see that certainly its mechanical and civil engineers are properly trained in the knowledge and possibilities of it.

MR. H. R. SWARTLEY, JR. (*Union Carbide Sales Company*).—In Mr. Moulder's paper in the concluding paragraph there is a thought that I think this Society could well bear in mind, and that is the necessity for a standard basis of uniformity. Either welding is going forward very rapidly toward that ultimate goal its obvious advantages entitles it to reach, or it is going to be set back in its progress.

Whose job is it to see that it goes forward, and who will be responsible if it goes backward? I think that is a responsibility that lies largely with us, the American Welding Society. He speaks of possible or pending legislative matters. That is not a mere statement; that is an actuality. Some of the factors that will enable us not to influence but to plead with the legislatures or their representatives, and give them advice, counsel and help when they want it, are clearly stated by Mr. Moulder, who properly asks: "Should not that specification not only cover materials, welding procedure, test of finished work, but also set up a definite plant of action looking toward rigid licensing of those manufacturers whose shop and field methods and whose integrity and responsibility are such as to warrant their being publicly recognized," to entitle them to sell products and to exhibit in competition with other methods? Do you not think that there is a large proposition which should be kept before us and give us all a lot of work to do?

Discussion Paper on "Arc Welding as a Manufacturing Process"

By H. M. HOBART and W. SPRARAGEN

BOSTON, MASS., Oct. 22, 1925, 10 a.m.

The session was called to order by President A. G. Oehler. President Oehler presented Mr. E. H. Ewertz as chairman. Chairman Ewertz then introduced Mr. W. Spraragen, who summarized the paper entitled, "Arc Welding as a Manufacturing Process," by H. M. Hobart, chairman, Electric Arc Welding Committee, and W. Spraragen, secretary. This paper was printed in the October, 1925, issue JOURNAL AMERICAN WELDING SOCIETY.

DISCUSSION

CHAIRMAN EWERTZ (*Bethlehem Shipbuilding Corporation*).—I anticipated that Mr. Spraragen would have something up his sleeve in turn for a little note that I wrote him when I asked him to be sure and be present at this meeting. [Reference is had to the following sentence in the paper presented.] "Although the plan of using arc welding instead of riveting for joining the hull plates of ships has been reported upon favorably many times by men of unquestioned authority, wide experience and mature judgment, the use of riveting for this purpose appears to be so strongly entrenched that it will not be likely to be replaced by welding on any considerable scale until those at present in control of the shipbuilding industry have been succeeded by younger and more enterprising and open-minded men."

I think he came nearer hitting the truth than he realized himself, although he kindly made an exception in my case. It is quite true that the older generation of today will have to disappear or, in other words, that it is going to require probably another 15 or 20 years to change the minds of the engineers, take them out of the rut which they are in today, which has been formed over a period of years and start them in on a new road.

It takes people like you gentlemen here to bring out the facts so that the rest of the engineers may see that you know the facts as they are. I had the pleasure of going out of town some months ago and visiting a shop, and I was just amazed to find out the volume and the vastness of the use of welding in industry. It was way beyond anything that I had ever dreamed of. I thought I was pushing things pretty fast, but there they were using it in ways that I would not have dared to ask anybody to do.

The paper just read, as I said before, has got some wonderful thoughts in it and should be discussed with a great deal of interest.

MR. JAMES W. OWENS (*Welding Aide, Norfolk Navy Yard*).—In this paper the authors have concisely summarized the art of

*Printed in October, 1925, Journal of the A. W. S.

metal arc welding in its relation to manufacturing processes. Such a summary should be of material assistance in calling the attention of engineers and executives to the infinite possibilities of arc welding as a commercial tool and go a long way toward breaking down the extreme conservatism of those who through training and temperament refuse to acquaint themselves with, or to authorize the use of this method of joining metals.

The reasons usually advanced by our conservative friends for their non-use of welding are that the "strength of the weld is

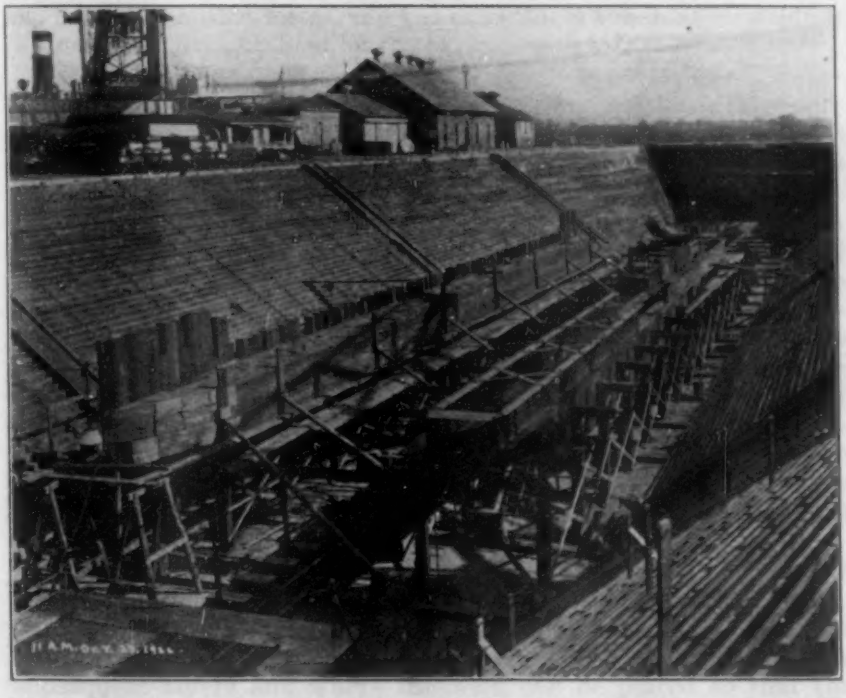


Fig. 1. Metal arc welded battle towing target under construction at the Norfolk Navy Yard (riveted target shown on left and welded target on right)

entirely dependent on the operator" and that "the welded joint cannot be tested." It is to be hoped that these individuals will give particular attention to the fallacy of such arguments as presented by the authors. In this connection I will say that if today a weld fails because of poor workmanship, the fault lies with the designer or supervisory force, for welding engineers have conclusively proved that the ability of a welder can be accurately evaluated prior to his assignment to a job. With this factor of uncertainty eliminated, the structure properly designed for welding, and correct welding technique employed, there is no more need of testing the welded structure than there is of requiring tests of every brick or concrete structure built.

About eighteen months ago at my recommendation the Boston

Navy Yard tested every welder employed, and it was found that some of those rated as "first class" were not competent welders, while others having a lower rating were entitled to a first class rating. One welder was found to be totally incompetent and was discharged. These tests have been repeated periodically every six months. Those rated as first class welders as a result of the first test have been found to be equally competent in the subsequent tests; those rated as "second" and "third class" welders have shown improvement in each subsequent test; while the welder found to

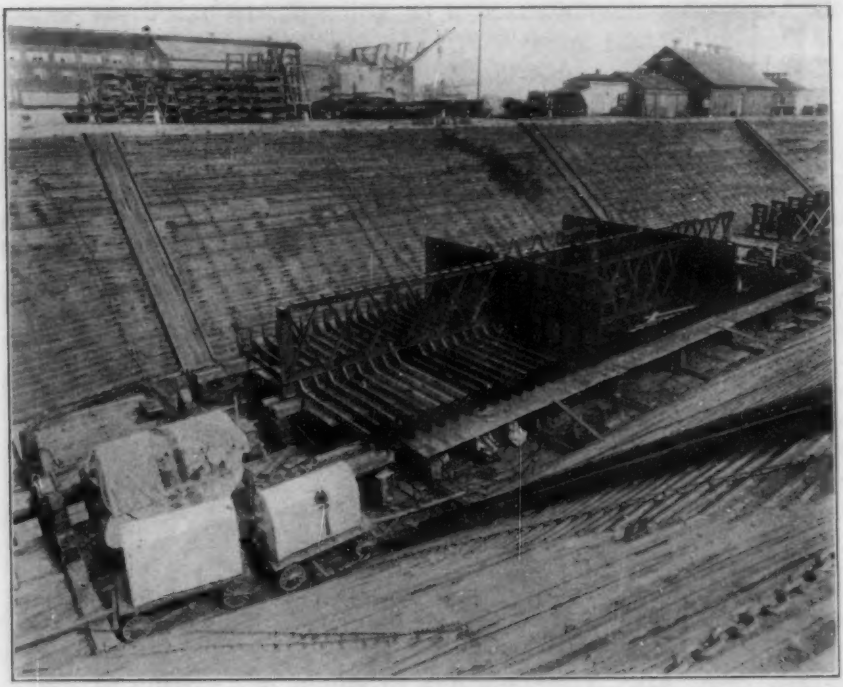


Fig. 2. Pontoon for 120 ton derrick under construction at the Norfolk Navy Yard, in which shell plating, deck and two bulkheads will be welded by the metal arc (welded bottom and bulkheads shown)

be incompetent was given an opportunity to qualify on two other occasions, and in each instance failed to do so, although working as a welder outside of the Navy Yard. These tests tend to prove the necessity of testing all welders, and the claims of welding engineers that good welders can be selected. They also indicate that a welder once having mastered the art remains a good mechanic, provided he is constantly employed on welding.

The authors specify a maximum base metal carbon content of 0.20 per cent for good welding. My experience indicates that, although standard ship plate has a carbon content of 0.25 per cent, it can be satisfactorily welded; however, due to its greater resistance to cooling stresses, lap and tee joints should be used exclusively, unless the contour of the structure permits the relief of

these stresses. Even in steels within the lower carbon range, the lap joint is in general preferable to the butt joint in material above ¼ in. in thickness, for the cost of bevelling the edges is eliminated, assembly is easier and welding conditions are better. The lap joint having better thermal characteristics, larger electrodes and higher current values can be used, thus further reducing the cost.

Some engineers have suggested the use of a composite joint embodying both riveting and welding. Personally, I cannot see the advantage of such a joint, for the welded joint is superior to the riveted joint, at least when ingot iron and medium carbon steel are used as the base metal, and the advantages inherent in welding can only be fully obtained by the exclusive use of welding.

With the first advent of arc welding there was a dread of "burning" the metal, with the result that small electrodes and low current values were used for all thicknesses of plate, the size of these electrodes rarely exceeding ⅛ in. diameter. Today this fear has nearly disappeared, and 3/16 in. and ¼ in. electrodes are in general use. In manual welding, there is no increase in the current density in these larger electrodes, although the current values used are higher. By their use, poor penetration, which was once prevalent and frequently resulted in weld failure, is today almost unknown, for the size of electrode and current value used takes into consideration the thermal capacity of the joint.

I have been informed that 400 amperes have been successfully used for 3/16 in. electrodes in an automatic machine. This is possible because the electrode is gripped close to the arc. Very high current values are impossible in manual welding, for it is necessary to grip the electrode some distance from the arc, which results in the heating up of the electrode.

Electrodes of ⅜ in. diameter, when used for the first layer of fillet welds, have a tendency to arc from their circumference instead of from the center, and the welder also finds difficulty in placing the metal where it will be most effective; however, for subsequent layers and where the weld can be placed so that the force of gravity can be used to determine its contour, their use will materially increase the rate of metal disposition. Electrodes of 3/16 and ¼ in. diameters are about the largest that can be satisfactorily used respectively for overhead and vertical welding.

A point not touched on by the authors is the necessity of adequate power supply. When electrodes and current values suitable for the thermal capacity of heavy material are used, it will usually be found that the K.w.h. capacity of the equipment on hand is inadequate. As much consideration should be given to the purchase and installation of suitable welding equipment as any other power equipment used in manufacturing processes. The authors state that "a highly skilled operator with special electrodes can produce an arc weld which will break in the plate every time." My experience is that these results can be consistently secured on medium steel ship plate with standard bare low carbon steel elec-

trodes, complying with the A. W. S. specifications, and all standard ship plate, pipes and pipe fittings in the Naval service are welded with these electrodes. Special jobs using alloy steels, will require special electrodes, but such jobs are a very small proportion of the total work which is being done, or can be done with bare low carbon steel electrodes complying with the A. W. S. specifications.

The figures given by the authors for the tensile and shearing strengths of weld metal are considered satisfactory. I am, however, using 36,000 lb. per sq. in. for both the tensile and shearing strengths. The modulus of elasticity of weld has been determined by me to be less than that of medium steel, and 32,000 lb. per sq. in. is taken as its elastic limit.

The following tables give the sizes of electrodes, current values and rates of welding secured at the Norfolk Yard on 45-ton battle towing targets:

Current values used for 3/8 and 1/2 in. plates

3/16 in. bare electrodes—185 to 225 amperes
1/4 in. bare electrodes—200 to 250 amperes
3/8 in. bare electrodes—250 to 375 amperes

		Weight of metal (lb.) deposited in weld (allowing 20% for waste)		*Ft. per hour (fillet weld)*	
Target	*Size of electrodes used*	*Av.*	*Max.*	*Av.*	*Max.*
A	3/16 and 1/4.....	2.4	3.2	7.73	11.3
B	3/16, 1/4 and 3/8.....	3.3	5.03	8.5	12.3

NOTE.—The greater proportion of welding was on 3/8 in. material in the flat position. Full fillet welds were used exclusively.

The cost of the steel keel of three targets was approximately 34 per cent less than that of riveted targets of similar design and which were constructed simultaneously to obtain comparative costs of the two methods of construction. The weight of the welded targets was 11 per cent less than the riveted targets. Among the large quantity of work which has been done at the Norfolk Navy Yard by means of metal arc welding during the past seven years may be mentioned:

(a) Seven completely welded battle towing targets, 172 ft. long and of 45 tons weight. Two more are now under construction at the Norfolk Yard and two at the Puget Sound Yard.

(b) A pontoon for a 120-ton derrick is now under construction. The entire shell, deck and two bulkheads are welded. The pontoon is 132 ft. long, 35 ft. 10 in. beam, and 12 ft. molded depth. The shell plating is 3/8 in. and 1/2 in. ship plate, and there will be a total of 6652 ft. of fillet welding.

(c) One 4 in. steam line, 125 lb. working pressure, 1000 ft. long.

(d) One 4 and 6 in. steam line, 125 lb. working pressure, 2800 ft. long.

(e) One 3 and 4 in. steam line, 125 lb. working pressure, 4000 ft. long.

(f) One 4 and 6 in. steam line, 125 lb. working pressure, 1500 ft. long.

(g) One 1¼ to 3 in. hydraulic shop piping, 200 ft. long and designed to withstand a working pressure of 1800 lb. This line was originally welded by gas, but subsequent extensions have been made by the metal arc. Butt joints were used in the line in all installations.

In conclusion I will state that much of the progress which the Navy has made in welding is due to the progressive spirit of some of the official personnel of the Bureaus of Construction and Repair, Engineering, Ordnance, and Yards and Docks. Captain Henry Williams, C. C., U. S. N., manager of the Norfolk Yard, having been convinced of the infinite possibilities of welding in naval construction, has been conducting an active campaign among the various bureaus for its extension. This campaign has commenced to bear fruit, and it is believed that the increase in welding will be very marked in the near future.

CHAIRMAN EWERTZ.—We are very much indebted to Mr. Owens for his remarks, particularly so as he represents an organization, the Navy, which is primarily trying to develop mechanics for the benefit of the country as a whole, rather than for itself, and we can get tests and facts that may be very difficult to obtain from manufacturers, but that are given us freely by the Navy. We certainly appreciate very much having had this discussion by Mr. Owens.

MR. A. G. BISSELL (*Westinghouse Electric & Manufacturing Company, Pittsburgh*).—I think you may be interested to know that, besides ships sailing on the water, they are using arc welding in construction of airplanes. One concern is using arc welding in the construction of fuselage. One of their planes had a little hard luck in getting off from San Francisco this fall, but yet they are trying to make the all-American flight this winter, and that plane has a welded fuselage. It is a step higher perhaps, going into airplane construction, than in ship construction, and I thought you would be glad to know of it.

CHAIRMAN EWERTZ.—I have had the privilege of going out in ships, although I think they were not welded, and I have been under the water in submarines not welded, but I confess I have not had nerve enough to go up into the air, whether the airplane was welded or riveted.

MR. HOVEY (*of Manchester*).—I want to ask two questions: First, to what extent has the art of welding been used in structural steel frame work? And the second question is, what do tests prove to be the value of arc welding under vibration?

MR. SPRARAGEN (*Secretary, American Bureau of Welding*).—In

answer to the first question, I refer you to a paper written by Goldmark, Warner and myself, published in the October, 1924, issue of the JOURNAL OF THE AMERICAN WELDING SOCIETY. That paper will show you twenty or thirty applications of arc welding in structural work.

When it comes to vibration, I would state that the Westinghouse people have made some tests. Mr. Bissell of their company is here, and I would rather he describe them in detail. It shows in those particular tests that welding withstood vibration and shock much better than riveted structures. For actual figures in designing work, there has got to be a lot of research done in obtaining definite figures on the fatigue limit. We call the ability to withstand vibration and repeated stresses fatigue. I refer you also to one section in this paper: "Although at present there does not exist a great deal of data as to the fatigue strength of weld metal, a few tests that have been conducted indicate that one-half of the ultimate tensile strength may be employed as an ultimate endurance limit below which an arc weld will not break for millions of cycles of repetitions of stresses." The tensile strength is given for certain conditions as 40,000 pounds per square inch of weld. Under those same conditions the fatigue endurance limit would be 20,000 pounds per square inch, and in that way you can get figures which would be useful in design work.

MR. A. G. BISSELL.—Before we went into this to any great extent we made some rather conclusive tests. We took a 10-in. I-beam 25 lb., and welded it to a piece of 1-in. plate fillet weld, and to the base of that we welded two 6-in. I-beams with a fillet weld between the 6-in. and 12-in. I-beams, placing a 6-in. I-beam on opposite sides of the weld. We also attached two 6-in. I-beams with a fillet weld. The 6-in. I-beams were 2 ft. long. That was bolted down to the movable body of a vibrating machine used in testing railway equipment, and was subjected to vibratory or vertical movements of 1/16 of an inch, at the rate of 1760 complete cycles a minute. We shook or "shimmied," as we call it, the test piece for 19 hours. I think there is a pamphlet in our booth with the exact figures in it, and this test showed no failure of the welded joint. Then, to accelerate the test we added a 25-lb. weight to each 6-in. I-beam, and we continued that test I think for a little better than an hour, when the web, through fatigue, failed and tore out a section, removing both of the I-beams, but the I-beams were intact with each other. Through the web they were solidly connected. Continuing the test for about 20 hours longer, or a total of about 39 hours altogether, the web of the 10-in. I-beam broke down, probably due to the web of the 10-in. I-beam cracking from the top. We ran for another hour, hoping that perhaps we might get other failures, but the I-beam was so badly broken up and was rattling so that we had to discontinue the test.

Therefore, when we repeated the test we added several other sections. In one case we took a single beam 6 by 12 in. of 25 lb.,

having less than 3/8 in. contact on each side of the fillet around the entire 6-in. I-beam. In the second set of I-beams we welded the web alone. The way which the web was welded caused failure in the web from fatigue, about 3/16 of an inch back. The one welded by a single bead fillet did not break. The one that did break was because the I-beam attached to the web failed and broke out the web of the 10-in. I-beam, leaving only a small section holding the I-beam. This shows that a joint of that kind will stand up under vibration very well.

MR. SPRARAGEN.—The matter of fatigue is pointed out in this paper as one of design. Welds will stand tensile stresses better than fatigue. So that it is a good thing, if possible, to have the design such that the weld is subjected to tension rather than to bending and fatigue.

Another reason why we favor the lower carbon plate is that, if the weld is made in the low carbon plate, the weld being the stiffer of the two, especially if it is reinforced on each side in a butt joint (your lap weld is certainly stiffer), the stresses are shifted outside the weld, and the rolled plate is much better able to withstand such vibratory stresses.

MR. WESLEY B. THOMPSON (*Boston & Albany Railroad, Boston, Mass.*).—I would like to ask what the records are in regard to corrosion.

CHAIRMAN EWERTZ.—Corrosion from what, air, water or acid?

MR. W. B. THOMPSON.—From air, water or perhaps gases.

MR. SPRARAGEN.—Some people here have made more extensive investigation than I have on that subject. I have not found anything to fear from corrosion on arc welds, or even gas welds, and I would refer to some tests where plates were welded on the bottom of ships, and then inspected every time they came into port. Mr. Bissell was at that time connected with the Puget Sound Navy Yard and made some experiments, as did also Mr. Owens of the Norfolk Navy Yard.

MR. BISSELL.—The one instance that Mr. Spraragen refers to, which I think was in regard to a rudder on a battleship, we found that the rivet heads did show some corrosion; also alongside of them were rivet heads that did not show corrosion. The fact is that the corrosion on the rudders was due strictly to electrolysis between the propellers of the steamship. But the other portions of the ships where they were not subjected to electrolysis showed no more corrosion on the deposit than on the ship plate itself. You will find the weld is a very mild steel if properly put in, and you will get no more corrosion in that welded joint than from an ordinary steel joint. Possibly less in some cases because of the lower carbon content in the average weld than in the steel.

MR. JAMES W. OWENS.—With reference to the tests that Mr. Spraragen referred to, some plates about 6 in. square with a butt weld in the center were attached to the sides of various ships and were observed for eighteen months, I suppose. No difference in

corrosion was noticed between the weld metal and the base metal. There is now being conducted a test to determine whether the alternate use of salt water and gasoline against the joint will influence corrosion. This is being done in connection with the use of gasoline tanks by the ships in which, as the gasoline gets lower, the tank is filled up with salt water. These tests have been under way for the period of about six months, and some of the welds were just left as they were made, and others were drummed off. On the examination which I made of them a few days ago, I found no more corrosion on the plate than there was on the weld.

In this test two buckets or receptacles, one with salt water and one with gasoline, are used, and the plates are alternately put in, one week in salt water, and the next week in gasoline. As far as the result of corrosion in practical work is concerned, I have not noticed any more corrosion in welds than in rivets.

MR. C. J. HOLSLAG (*Electric Arc Cutting & Welding Company, Newark, N. J.*).—A little over ten years ago a lot of welds were made while I was working for the railroad in roundhouses where sulphur fumes were continuously in operation. I recently had occasion to look at those welds, and there does not seem to be any corrosion.

Also about eight years ago the bases of a railroad transmission tower subjected to salt spray had corroded so that they had to be turned down and welded. All the corroded spots on the steel were welded eight years ago, and since then there has not appeared any corrosion, so that there does not seem to be any ordinary condition which will cause corrosion.

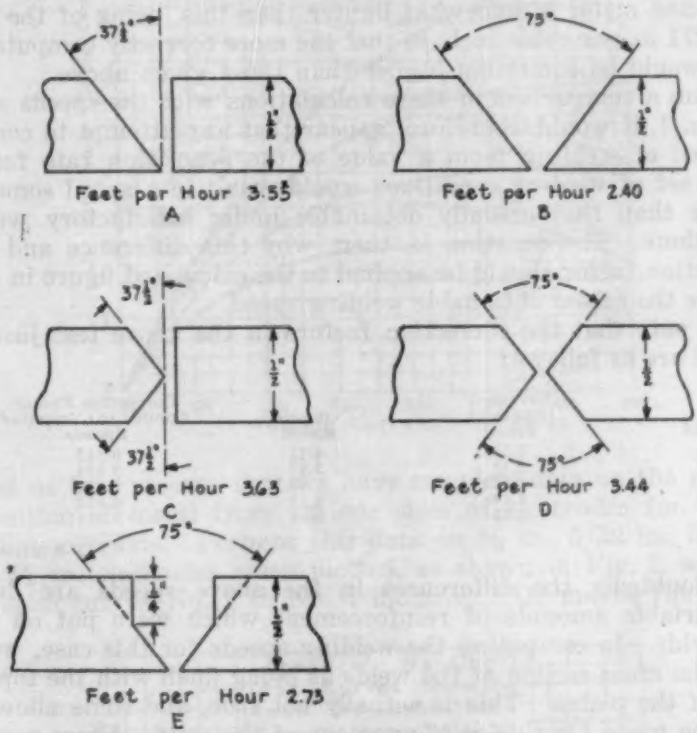
I want to emphasize what Mr. Spraragen said about making the weld stronger. In all the experiments that I have seen the appearances are that the weld could have been made strong enough so that the strains would have had to go to the plates.

MR. W. WALSH (*White Machine Works*).—We had quite a lot of electric welding on guards for machine frames and belts. One of the big guards doubled up for about 10 ft. with all fittings. We took and hammered it right out and let it go so that I think that covers the tensile strength question pretty well.

MR. W. L. WARNER (*General Electric Company*).—In the present instance the speed of welding is given in pounds of metal deposited per hour. Over a period of years and from observations made of a great number of welding operators fairly definite average values of rates of deposition of metal have been obtained. It has been found that these rates of deposition vary with the current and size of electrode used. From this data, then, if it is available, a table could probably be made up, showing the various rates of deposition of metal for each size of electrode and current used.

Having such a table of deposition rates, one may theoretically figure the rate of welding in feet per hour or inches per minute by determining the volume of metal required to fill the weld groove satis-

factorily. Obviously, as Messrs. Hobart and Spraragen point out, the speed of welding in feet per hour will vary, under the same rate of metal deposition, with the preparation of the joint to be welded and other features. As an example of this, I wish to cite some of the tests which are now being carried on at Union College, Schenectady, with the welded samples which were made for the Emergency Fleet Corporation in 1918 and 1919. I refer to test No. 8.



Design of Welds on ½" Plate.
(⅛" Electrode 150 Amperes 16 Volts)
Fig. No. 1

In this test five different types of butt welds as shown in Fig. 1 were included. An electrode ⅛ in. in diameter with 150 amps. and 16 volts at the arc were used for all five tests. The material was ½ in. ship plate. The observed rate of deposition of metal for the five welds varied from 1.92 lb. per hour to 2.52 lb. per hour. These figures for the five tests give an average rate of deposition of 2.18 lb. per hour. On the basis of this average rate of deposition, the corrected observed speed of welding for each type of weld is shown in Fig. 1 under each type of weld illustrated.

It is interesting to note further that the free distance in all cases was ⅛ in., and that the computed speeds of welding in feet

per hour for a flush weld based on the average rate of deposition of 2.18 lb. per hour are as follows:

Weld	Cross Section	Feet per Hour	Weld	Cross Section	Feet per Hour
A	0.159 sq. in.	4.11	D	0.159 sq. in.	4.11
B	0.255 sq. in.	2.57	E	0.207 sq. in.	3.16
C	0.111 sq. in.	5.89			

For computing these figures the unit weight of the deposited metal has been taken as 0.278 lb. per cubic inch. Actually the arc deposited metal is somewhat lighter than this, being of the order of 0.271 lb. per cubic inch, so that the more correctly computed figures would be somewhat higher than those given above.

From a comparison of these calculations with the speeds shown in Fig. 1, it would, therefore, appear that any attempt to compute a speed of welding from a value of the deposition rate for any given set of welding conditions would result in a speed somewhat higher than that actually obtainable under satisfactory welding conditions. The question is, then, why this difference and what correction factor should be applied to the calculated figure in order to give the actual obtainable welding speed.

We note that the correction factors in the above test just discussed are as follows:

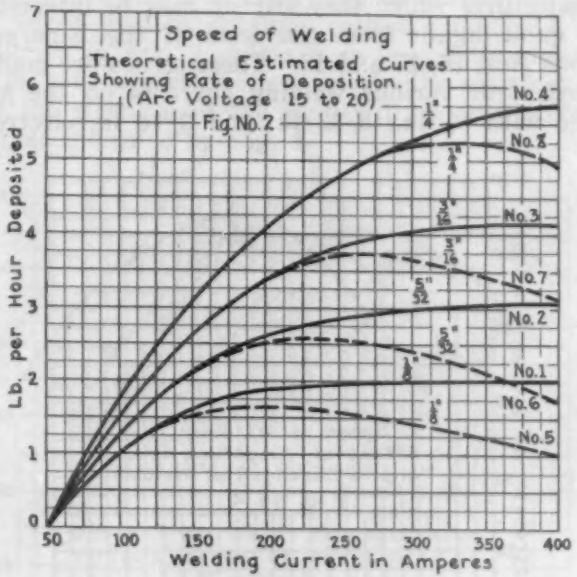
Weld	Corrected Observed Speed	Computed Speed	Correction Factor Applied to Computed Speeds
A	3.55	4.11	0.863
B	2.40	2.57	0.934
C	3.63	5.89	0.616
D	3.44	4.11	0.837
E	2.73	3.16	0.864
			0.827 Average

Undoubtedly the differences in the above speeds are due to the variable amounts of reinforcement which were put on various welds. In computing the welding speeds for this case, we figured the cross-section of the welds as being flush with the top surface of the plates. This is actually not true, and some allowance must be made for this reinforcement of the weld. From a casual inspection of the correction factors, given above, we may arbitrarily choose a provisional figure of 80 per cent for arriving at actual welding speeds from computed speeds which are theoretically based on a flush weld.

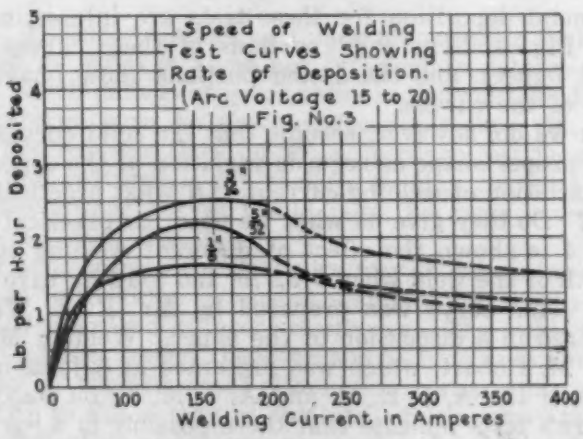
It may also be interesting to note that in the above test the average yield point varied from 30,170 to 32,075 lb. per square inch of plate section, and the ultimate strength varied from 47,050 to 54,700 lb. per square inch of plate section. These results show, therefore, that all of these types of weld in Fig. 1 give consistently good strength, which is well above the minimum of 40,000 lb. per square inch advocated by the American Bureau of Welding for the A. S. M. E. Code for Unfired Pressure Vessels.

Another aspect which, from a purely research point of view, has not been touched upon as yet is that of the quality and strength of the weld as affected by the speed of welding. Not having any

comprehensive or conclusive test data on this point, the writer is somewhat handicapped. However, by making certain assumptions perhaps some conclusion can be reached.



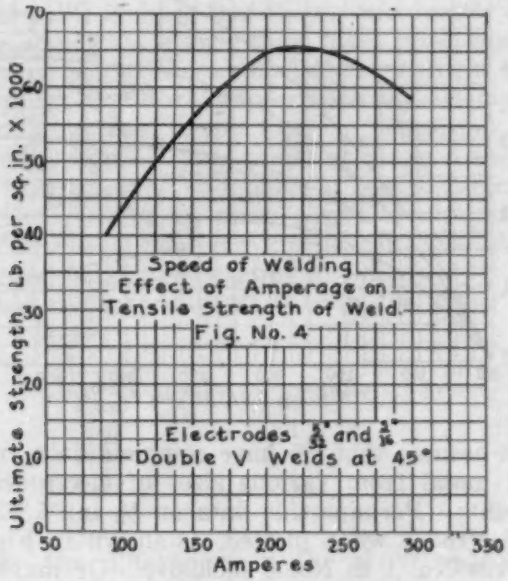
Let us first assume that we have complete data on the rates of deposition of metal from various sizes of electrodes for various welding currents. Perhaps this data on ⅛ in., 5/32 in., 3/16 in. and ¼ in. electrodes when plotted, as shown in Fig. 2 will give the solid curves No. 1 to No. 4 inclusive. Or maybe the figures



when plotted will instead give the dotted curves No. 5 to No. 8 inclusive. It is impossible to tell which is nearer correct. If the curves, however, do bend down, as shown by the dotted lines, it

means that there are economic limits beyond which the welder cannot increase the speed of metal deposition by increasing the current. It should be realized, however, that these curves shown in Fig. 2 were only imaginary and not founded upon cold facts, but the conjectures which they stir up may be interesting.

Let me quote again from the tests of the Emergency Fleet samples tests Nos. 16, 17 and 18. These tests were made to determine the effect of various welding currents on the strength of welds made with ⅛ in., 5/32 in. and 3/16 in. electrodes. The



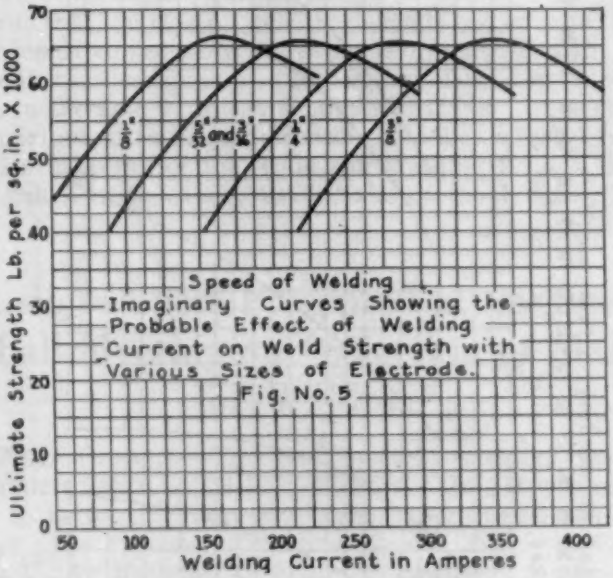
rates of metal deposition for these tests are interesting and are shown in Fig. 3. The solid portions of these curves show the actual test figures, and the dotted portions show imaginary continuations of the curves.

Suppose we do, however, assume that the solid curves of Fig. 2 are of the proper shape as regards variation of the deposition rate with the variation of welding current. Of what practical value are such data? Do they give us what we need for practical purposes?

In Fig. 4 is shown the effect of different welding currents on the strength of the weld when 5/32 in. and 3/16 in. bare electrodes are used. This curve was prepared by Mr. R. E. Wagner and first appeared in a discussion of the paper, "Welding Mild Steel," by Mr. H. M. Hobart, which was presented at a joint mid-winter convention of the A. I. E. E. and A. I. M. E. on Feb. 19, 1919. Mr. Wagner's tests indicate that there possibly is a current value which gives best physical characteristics to the deposited metal. If Mr. Wagner's figures are correct for the 5/32 in. and 3/16 in. electrodes with double V welds, as they happen to be in this case,

possibly the curves shown in Fig. 5 may be approximately indicative of the effect of welding current on weld strength when using other sizes of electrodes on a similar type of weld.

Now, if the above curves are truly representative, then the speed of welding which may be obtained cannot summarily be figured from the curves in Fig. 2 unless it is first determined that the current to be used lies somewhere within the satisfactory range, i.e., so that the strength of the weld will be over 40,000 lb. per square inch, as indicated by Fig. 4.



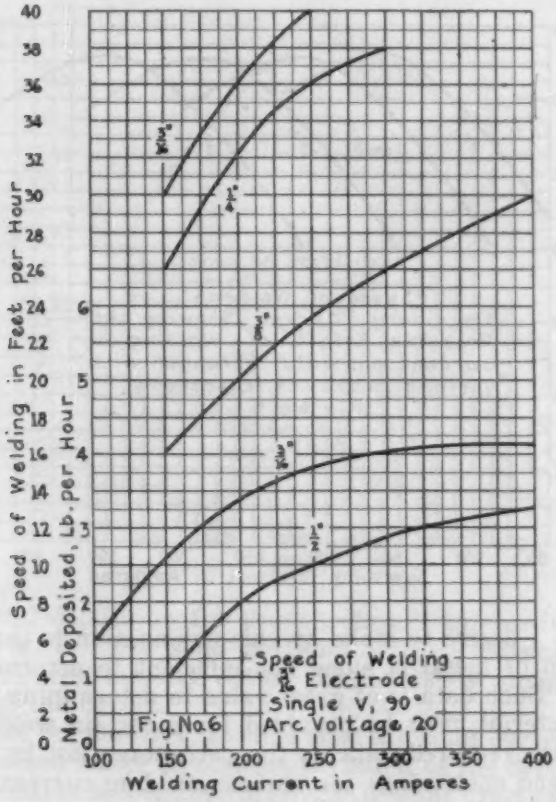
The point I desire to make by this explanation is that the rate of deposition of metal is alone not sufficient to determine a rate of welding. Such data is of great value in determining how much electrode material must be provided for a certain weld, but even here there are required data on the percentage lost by oxidation, scrap ends and spatterings for various welding currents and perhaps such percentage curves would take the same general shape as the solid curves of Fig. 2.

In the writer's opinion the only sure way to determine the speed of welding is to make an extensive series of tests with different thicknesses of plate and different electrodes. The welds should be subjected to tension, impact, bending and fatigue tests and the best welds noted. By the process of elimination perhaps curves similar to those shown in Fig. 6 may be obtained. Such curves then would give a true indication of the proper speed to be obtained.

Another advantage of curves like those shown in Fig. 6 is that the welding speed on thin material and material below ¼ in. in thickness can be clearly given. This cannot be done in terms of

pounds per hour. As an example, let us consider the welding of 3/32 in. material. Suppose we decide to use a 3/32 in. electrode with 100 amperes and under these conditions we know that, say, 1 lb. of metal can be deposited per hour. How would you figure the speed of welding? In fact you wouldn't. You would either guess at it or else experiment a little until you found the proper speed which would give a smooth, good looking weld.

In fact, it would be almost impossible to calculate the speed of welding in this case unless arbitrarily you had decided upon the



amount of reinforcement to be used and the free distance between the pieces to be welded. Such selection would naturally be based on accurate test data in which the criterion would be the physical properties of the weld.

In conclusion then I would say that the determination of speed of welding from a predetermined rate of deposition of metal above would be unsatisfactory and extensive tests must be made or authentic data must be available for determination of welding speed. This is a research problem and one such as the American Bureau of Welding should enjoy.

MR. SPRARAGEN.—If we recorded the speed of welding in num-

ber of feet that could be welded per hour, it would also be necessary to show what type of joint was being used. For general information the best way to do it is to record speed in pounds of metal deposited per hour, and then from the drawings the speeds in feet per hour can be easily computed. Areas should of course not be taken as flush with the plate, but about 15% additional cross sections should be allowed. This general information given in the paper is accurate enough to make estimates. Of course this method of making estimates will not be necessary when enough cost data becomes available for specific applications. However, in new work this information might be a life saver.

It is true that the rate of welding depends not only on the pounds of metal deposited per hour, but depends on the size of the electrode, the current, the type of joint, the position of welding, also whether done out in the field or in the shop, and I think I have covered the most important of those variables in the paper which I read at the first annual meeting of the American Welding Society, and which was published in the June, 1920, issue of the *Welding Engineer*.

Discussion Papers Presented at the Session of the Fall Meeting on "Selection of Materials for Welding"

PRESIDENT OEHLER.—The meeting this morning was to have been conducted by S. W. Miller. Unfortunately it was not possible for him to be here. There are three papers to be presented this morning: The first one, "Welding Wire a Factor in Good Welding," by C. A. McCune, Director of Research, American Chain Company.

(The manuscript of this paper will be found in the October, 1925, issue of the JOURNAL OF THE AMERICAN WELDING SOCIETY.)

PRESIDENT OEHLER.—I think because of the fact that these papers are closely allied that we can present all of them and open the meeting for discussion afterward. The next is entitled "High Strength Welds," and has been prepared by J. R. Dawson, of the Union Carbide and Carbon Research Laboratories.

(For manuscript see October, 1925, JOURNAL OF THE AMERICAN WELDING SOCIETY.)

PRESIDENT OEHLER.—I would like to call next on the author of a paper entitled "Weldability of Ferrous Metals," written by C. J. Holslag, Chief Engineer, Electric Arc Cutting and Welding Company.

(For full text of this paper see page 37 of October, 1925, issue of JOURNAL OF THE AMERICAN WELDING SOCIETY.)

PRESIDENT OEHLER.—I hope you are noting down your points for discussion. There are a number of things that have been said

which will give you splendid opportunity. I am going to be so bold, too, as to suggest that if you choose to do it we will accept controversial discussion, namely, on the subject which came up the other day relative to the respective merits of gas and electric processes. An executive is a man who decides quickly, and is sometimes right. I am going to take that chance, but I warn anybody that enters into such a discussion that if he presents opinions I shall ask him to sit down; if he has facts he can talk. It is up to me to try to decide which is which.

The last paper which will be presented before we throw the meeting open for discussion is entitled "Selecting Welding Wires" and it will be presented by H. M. Carter, the Oxweld Acetylene Company of New York.

(For the full text see page 29, October, 1925, JOURNAL OF THE AMERICAN WELDING SOCIETY.)

MR. SPRARAGEN (*Secretary, American Bureau of Welding*).—I would like to remove some of the mysteries of the covered electrode mentioned by Mr. Holslag. I do not see anything mysterious about it. Of course we do not understand all the phenomena that there are, but still we are trying to find out and will find out all about it eventually.

The flux covered wire skilfully handled might be better, if you take a good wire and cover it with a good flux. You may get better results particularly in welding alloy steels and high carbon steels than you will in mild steel with a bare wire which does not have the covering. I have found that all the test results over in England, where they use covered wire more than they use bare, show that the covered wire gives better results than bare wire; whereas, most of the test results in this country show just the opposite. The only reason I can see is that they might have better material over on the other side, having used it longer, and also that the welder over on the other side is skilled in the use of flux covered wire and not with bare wires, whereas the opposite is true over here.

MR. J. W. OWENS (*Norfolk Navy Yard*).—Mr. Spraragen's conclusions very largely agree with mine. I have found that in shipyard work a bare wire will do all that is required in a weld. The reason probably that the tests in Europe show more consistent results is that they use not merely the coated wire, but a covered wire in the majority of cases. At least that is my understanding of the situation there.

I will mention here that Mr. Spraragen's statement does not quite agree with the paper he presented yesterday, that by using special electrodes you could get a weld of 100 per cent. You can get a result of 100 per cent with good bare electrodes provided the proper amount of added metal is deposited in the weld. That is one condition, and if you do not do that, you will not get a 100 per

cent weld. You can secure a 100 per cent if the weld is properly reinforced.

In practically all cases they use a low carbon steel welding rod in gas welding. It has not been universal in electric welding to use a low carbon steel rod, and I think that with the low carbon steel welding rod carefully selected better results are secured. There is no reason, with suitable electrodes, why an electric weld should be any more porous than a gas weld.

MR. W. B. MILLER (*Union Carbide and Carbon Laboratories*).—There is no bare wire electrode on the market that is not coated. All rods are coated, as it is incident in the process of manufacture.

As to Mr. Dawson's paper, one of the most desirable features that high test rod is a complete absence of sparking. We all know that in use a large amount of heat throws quite a shower of sparks, and that the slag falls onto the line of welding and is later on absorbed by the welding metal. The use of silicon and manganese rods gives a cleaner surface and is one of the important factors.

MR. MCCUNE (*Director of Research, American Chain Co.*).—I would like to ask Mr. Miller what he means by coating. I know that not all rods are coated.

MR. W. B. MILLER.—There may be a few exceptions. Welding wire for arc welding is given a pickle and is drawn through it, and that is not removed as a rule.

MR. MCCUNE.—In answer to Mr. Miller, I do know of some wire which is not pickled in that way. That is the usual wire practice, but I know of a good many cases where after a wire is drawn it is cleaned and annealed.

MR. MILLER.—Then I will make my statement this way, that if a coating is on there, it is very likely to cause difficulty.

MR. MCCUNE.—The question, nevertheless, that Mr. Miller raises is one of importance. If the wire has slime on it, it will produce bad results.

MR. C. J. HOLSLAG (*Electric Arc Cutting & Welding Co.*).—I know that not all the arc welding wire I have seen is sand-papered clean. There is some coating on it.

MR. W. SPRARAGEN (*Secretary, American Bureau of Welding*).—I think Mr. Holslag's discussion is correct. You can destroy a good wire by sand-papering. It may be some surface phenomena, but the action of the electrode in the arc is not the same. This may be due to the electrical resistance of the surface of the wire.

Mr. Owens mentioned my paper of yesterday, and I believe the statement that I made in that paper is correct. I think it is well known that the lower the carbon content the easier it is to weld. With a lower carbon content plate, with a good bare wire, and also with a good coated wire, you can get a joint as strong as the plate. As the carbon content increases you cannot always do that with an ordinary wire, and that is what I had reference to.

Another thing which is not always understood: regardless of what process of welding is used in the higher carbon content plate,

there is a brittle zone which has been overheated. In electric welding it is nearer the weld, and in gas welding it is farther away, but it is always there regardless of the process.

MR. E. E. THUM (*Manager, Publicity Department, Union Carbide Company, New York City*).—As long as the electrode situation has been cleaned up, I want to call attention to a point which Mr. Holslag made in his paper, respecting the opinion that the Welding Society can do little or nothing toward specifying qualities of material to be welded.

I agree with Mr. Holslag that in general the man who actually does the welding is powerless to specify the material on which he welds. The man who is doing repair work or who is directing it is also usually powerless to select the material on which he welds. Broken parts are brought to him and he is told to fix them; so he takes what he gets and does the best he can. The big future of welding, however, is far and away beyond the repair field, and is in the field of production.

Unquestionably when a concern gets into production welding it is in a position to specify the material which is to be welded. If this is not done sooner or later trouble will be encountered. The forge welding people have not hesitated to go before the American Society for Testing Materials and this society has agreed upon specifications for material for forge welding. Just how much metal is bought under these specifications I am not prepared to say, but at least the matter has gone that far forward. It seems to me that if the forge welding people can do as much, the gas and arc welders, if interested sufficiently, can do the same thing. The American Welding Society should have as much voice in matters relating to welding as The American Society for Steel Treating has in matters pertaining to steel. The steel treaters have very definite ideas about the materials best suited for steel treating, they get up in meeting and say so, and the steel manufacturers pay very close attention indeed.

After you consider the desirability of specifications for welding material, you might next bring up the question of methods for determining whether the material is good for welding or not good. The answer to that question ought to come from the combined experience of such a society as this. Through properly constituted research committees it would not take long for a good opinion to be formed about what is wrong with samples of material which do not weld satisfactorily, these samples being sent in by members from various parts of the country.

Take another parallel from the Steel Treaters. A local Section of Steel Treaters might, for instance, decide that any steel which under heavy pickling develops deep pits or gashes is shown by such a deep etch test to be steel undoubtedly bad for treating, steel which will crack under quenching, and to be altogether undesirable. This deep etch test is questioned by the steel manufacturers. They do not like to sell steel and have it tested in such a way or in any

other way which they cannot anticipate. The Steel Treaters have not yet been able to get the deep etch test into written specifications, but unquestionably a very large tonnage at the present time is sold to plants where they are doing heat treating on a commercial scale with a written clause attached to the specification that it shall pass the deep etch test.

If there is a flame test for welding material, and apparently there is, I can see no reason why this or some other test which shows the same thing should not eventually be attached to a specification for steel of good weldable quality. The sooner all the people who are interested in production welding realize these things, and through such a body as the American Welding Society bring pressure to bear upon specifying bodies to write specifications for material to be welded, the better off the welding industry will be.

PROFESSOR C. A. ADAMS (*Harvard Engineering School*).—I was glad to hear what Mr. Thum had to say about specifying the quality of steel. It has seemed to me almost a necessity to have some specification; also that it is entirely possible that such specification would not interfere in any way whatever with the physical properties of the steel desired in the structure. It might be a little different from that used at present, but not necessarily inferior.

Just a word in connection with testing electrodes. The complications are almost unbelievable.

On the electrical end it has occurred to me ever since we had the automatic machine, that research work in the effort to determine the weldability of the parent metal, and the value of the different electrodes could be determined experimentally by the use of the automatic machine which eliminates the variability of the human factor, with a great deal more reliability than in any other way. I hope that through this Society or through some of its corporate members such experiments will be carried on, so as gradually to eliminate a lot of unimportant variables and get down to the real fundamental basis of the problem.

You have got a big problem which is immensely important, and I sincerely hope that this Society will be able to stimulate research work in this field, if it does not do it itself, to such an extent that the progress will be hastened way beyond what it would be without it.

MR. EDMUND VOM STEEG, JR. (*General Electric Company, New York*).—I would like to emphasize the importance of this research work being carried on in the materials to be welded by calling attention to what is being done in other industries. A large manufacturer recently has speeded up his production 20 per cent by changing the analysis of the steel, without sacrificing any of the quality of the material, and there is no doubt in my mind that that could also be done in the welding industry by specifying the steel to be welded, not only from the standpoint of weldability, but also in cutting down the cost of welding.

MR. J. W. OWENS (*Norfolk Navy Yard*).—I would like to rein-

force what Prof. Adams said on the matter of machines and the selection of electrodes. I think anyone who has ever used the automatic machines would tell you that pure electrodes can very easily be determined by their use, and I think that any scientific investigation adopted by this association for the determining of the suitability of various electrodes for welding should be conducted by an automatic machine for welding.

MR. CARL D. MILLER (*Burke Electric Company, Buffalo*).—I would like to ask a question of Mr. Dawson in connection with his paper on welding wire: Does the high test welding wire which he uses give ductility as well as strength?

MR. J. R. DAWSON (*Union Carbide and Carbon Research Laboratories*).—The weld metal itself has somewhat less ductility than weld metal obtained from Norway iron. It is only slightly less in that respect. But it has this advantage: if you make a weld, of which most are made in mild steel, the weld is stronger and stiffer than the mild steel. For that reason if any strain is placed on the structure, if the strain is sufficient to cause deformation, the deformation does not take place in the weld but in the base metal. Of course the test that I speak of, where you bend the weld backward, is an excellent illustration of that. If you make a test in which the elongation is 2 in., in a ½ in. plate, of course it will include quite a bit of base metal; if the fracture does occur in the weld the high strength of the weld will stretch the base metal within that distance. So that in most cases if you take a weld made with the high test rod and with Norway iron, and an elongation of 2 inches, the result will be higher for high test rods.

MR. FRED E. ROGERS (*Air Reduction Sales Company, New York*).—I would like to ask Mr. Dawson if the manganese content of the material affects the weld as regards rusting. In some cases it seems to me that the manganese content would affect the weld which would be likely to rust more than the lower mild steel or Norway iron.

PRESIDENT OEHLER.—Can you answer that, Mr. Dawson?

MR. J. R. DAWSON.—It is my opinion that the difference in rate of rusting would be negligible, but I have no facts on it.

Standardization of Hose Connections for Welding and Cutting Torches and Regulators*

Preface

Welding and cutting equipment is in use in almost every manufacturing plant, railroad shop and shipyard, and on construction, erection and demolition jobs all over the country. In fact, gas welding and cutting equipment is universally used. There are in all twenty-five or thirty or more different makes of torches, regulators, etc., which in the past have been equipped with various diameters and threads for hose connections. Lack of uniformity in the design and size of these fittings has caused users of equipment considerable trouble in providing adaptors and making connection between different makes of torches, regulators, etc.

In order to eliminate this inconvenience in connecting up one make of torch with a different make of regulator or vice versa, the manufacturers of welding and cutting equipment have established a standard for hose connection, nuts and nipples for both torches and regulators, which will soon become effective. After an exhaustive discussion of the subject by the Gas Products' Association, the International Acetylene Association, and engineers and other representatives of apparatus manufacturers, a standard thread and a standard design of nut and nipple have been developed and adopted.

The two associations mentioned above have been cooperating to obtain the acceptance of this standard, and up to the present time the following apparatus manufacturers have accepted the standard and agreed to make it effective beginning January 1, 1926: Air Reduction Sales Company, New York City; The Bastian-Blessing Company, Chicago, Ill.; Burdett Manufacturing Company, Chicago, Ill.; Harris-Calorific Company, Cleveland, Ohio; Imperial Brass Manufacturing Company, Chicago, Ill.; Alexander Milburn Company, Baltimore, Md.; Modern Engineering Company, St. Louis, Mo.; Oxweld Acetylene Company, Newark, N. J.; Purox Company, Denver, Colo.; Smith's Inventions, Inc., Minneapolis, Minn.; Torchweld Equipment Company, Chicago, Ill., and United States Welding Company, Minneapolis, Minn. These companies combined produce the greater portion of welding and cutting apparatus and equipment manufactured in this country. Negotiations are being carried on with other equipment manufacturers with a view to making the acceptance of this standard as nearly universal as possible.

The standard has already been approved by the American Welding Society, the Gas Products' Association, Chicago, Ill.; the International Acetylene Association, New York City, and the Underwriters' Laboratories, Chicago, Ill. It is under consideration, but has not yet been formally approved by the Bureau of Standards, Compressed Gas Manufacturers' Association, National Safety

*These standards were approved by the Board of Directors, A. W. S., at a meeting held in Boston, October, 1925.

Council, and the United States Navy. It is anticipated that favorable action will be taken by these bodies in the near future, and that the standard will be universally recommended and adopted in the United States.

In establishing this standard design for hose, nuts and nipples very careful consideration was given by the committees appointed for this purpose to adopting a design of nut and nipple and size of thread which would produce a convenient hose connection sufficiently large to permit a plentiful supply of gas to pass through the nipple and yet avoid a clumsy connection or one heavier than necessary.

A second consideration was the elimination, as far as practicable, of the possibility of placing an oxygen hose upon a fuel gas nipple, or vice versa, and for this reason right hand threads were adopted for oxygen and left hand threads for fuel gas.

It was also recommended that the oxygen and fuel gas nuts be marked with distinguishing letters, and that the fuel gas nut be made with a groove of some sort around the hex to make it clearly distinguishable from the oxygen nut to operators, who could not read English letters.

A third consideration was the avoidance of exposed conical or rounded seats which might be damaged if struck.

Various designs and types of nuts and nipples were considered from all points of view, and it was believed that the standard, as adopted, represented the most practical hose nut and nipple which could be found.

The adoption of this standard is considered a very important step in the right direction by those most familiar with welding and cutting equipment and its use as it will enable the user of such apparatus to connect up various makes of equipment quickly and conveniently and to avoid the trouble and inconvenience heretofore experienced when a hose sent out with equipment did not properly fit and could not be attached without special adaptors.

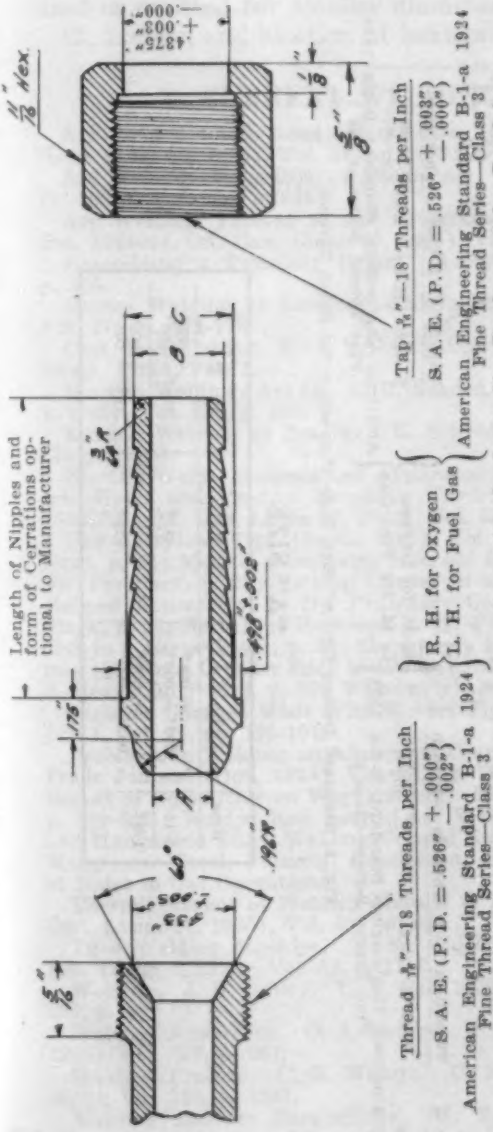
After January 1, 1926, manufacturers, who have accepted this standard, will make all new equipment with connections, which are in accordance with the standard and will provide means by which users of present equipment can connect up with the new apparatus. It is believed that the matter is of so much importance to users of equipment that those who are using a number of makes of apparatus will quickly take advantage of the arrangements made by manufacturers and change over old equipment to the new standard as promptly as it can be accomplished. The saving in time and money in using various makes of apparatus will undoubtedly offset the cost of such changes many times over.

Standards

In order that the new standard insure interchangeability of parts made by various manufacturers, it will be necessary to require manufacturers to hold certain dimensions within the limits of the drawings shown in Figs. 1 and 2.

Fig. 1 shows the "B" size nut and nipple, which is ordinarily used upon large torches and Fig. 2 the "A" size ordinarily used for small torches. The "B" size will be the standard for regulator hose connections.

In order that the manufacturers may use their own judgment or follow their usual practice, as far as possible, they are permitted to vary that part of the design, which does not interfere with interchangeability. For this reason standard and optional requirements have been definitely set forth, as follows:



Thread $\frac{3}{8}$"—18 Threads per Inch
S. A. E. (P. D. = .526" $^{+.000"}_{-.002"}$)
American Engineering Standard B-1-a 1924
Fine Thread Series—Class 3
R. H. for Oxygen
L. H. for Fuel Gas

Tap $\frac{3}{8}$"—18 Threads per Inch
S. A. E. (P. D. = .526" $^{+.003"}_{-.000"}$)
American Engineering Standard B-1-a 1924
Fine Thread Series—Class 3

Fig. 1. Standard Design of "B" Size Hose Connection for Large Size Torches and for Regulators

"B" SIZE

Hose	A	B	C
3/8"	.250" $^{+.003"}_{-.000"}$	.375"	.430" $^{+.000"}_{-.005"}$
5/16"	.187" $^{+.002"}_{-.000"}$	.3125"	.375" $^{+.000"}_{-.005"}$
1/4"	.125" $^{+.002"}_{-.000"}$	.250"	.312" $^{+.000"}_{-.005"}$
3/16"	.093" $^{+.001"}_{-.000"}$	.187"	.250" $^{+.000"}_{-.005"}$
1/8"	.062" $^{+.001"}_{-.000"}$	.125"	.187" $^{+.000"}_{-.005"}$

Standard Requirements

A. Size, type and kind of thread
B. Angle and outside diameter of female seat.
C. Radius and distance of radius center of male seat from nipple shoulder.
D. Diameter of nipple shoulder.
E. Diameter of hole in nut.
F. Small and large diameters of hose nipple.
G. Diameter of drilling through hole.

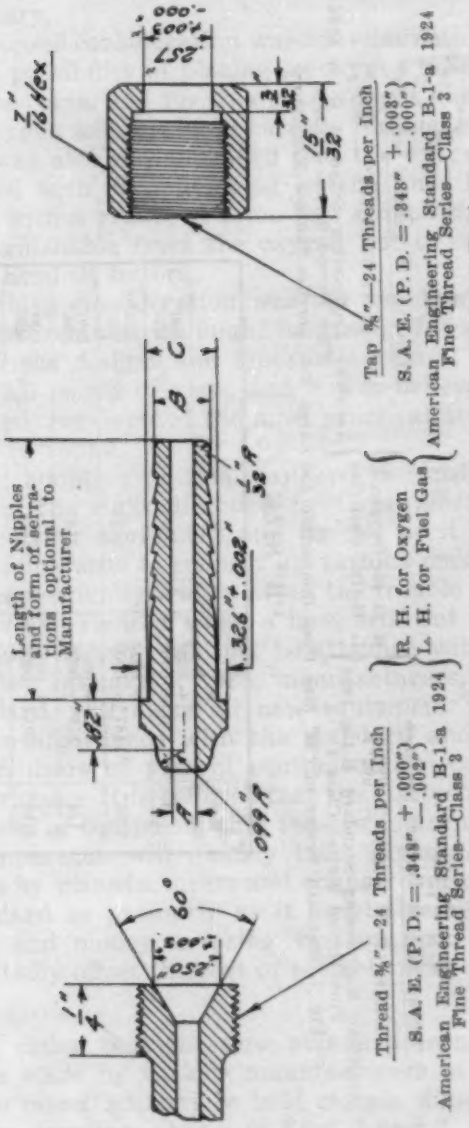

Length of Nipples and form of serrations optional to Manufacturer
Tap ⅜"—24 Threads per Inch
S. A. E. (P. D. = .348" +.003" −.000")
American Engineering Standard B-1-a 1924
Fine Thread Series—Class 3
Thread ⅜"—24 Threads per Inch
S. A. E. (P. D. = .348" +.000" −.002")
American Engineering Standard B-1-a 1924
Fine Thread Series—Class 3
R. H. for Oxygen
L. H. for Fuel Gas
.099 R
60°

Fig. 2. Standard Design for "A" Size Hose Connection for Small Torches

"A" SIZE

Hose	A	B	C
3/16"	.093" +.001" −.000"	.187"	.248" +.000" −.005"
1/8"	.062" +.001" −.000"	.125"	.187" +.000" −.005"

Optional Requirements

A. Material, strength equal to or greater than free turning high brass.

B. Diameter of drilling through male fitting.

C. Form of end of nipple, except seat section, as covered in "C" under "Standard."

D. Length of hose nipple.

E. Type and number of serrations on hose nipple.

F. A second shoulder equal to the large diameter of the largest nipple to extend through the hole in the nut for appearance to be used or omitted for smaller diameter nipples.

G. Length and location of hexagon section on nut.

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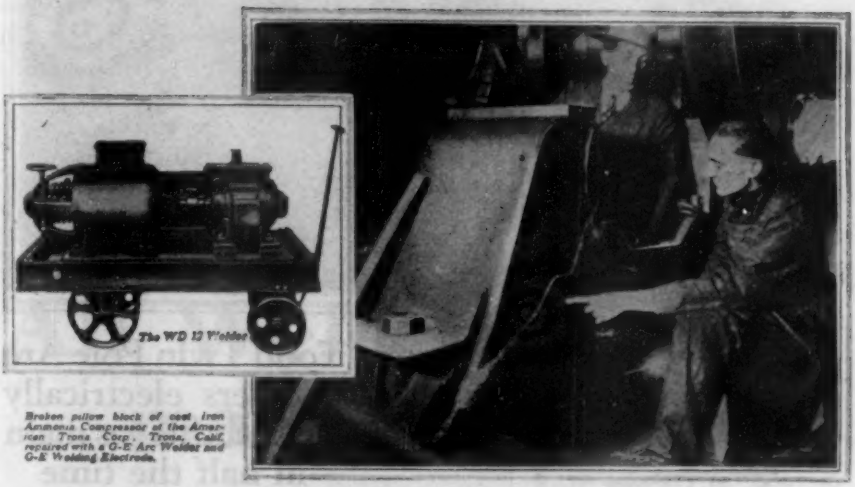

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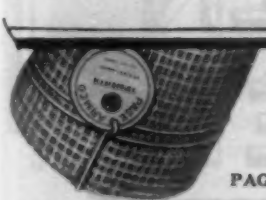

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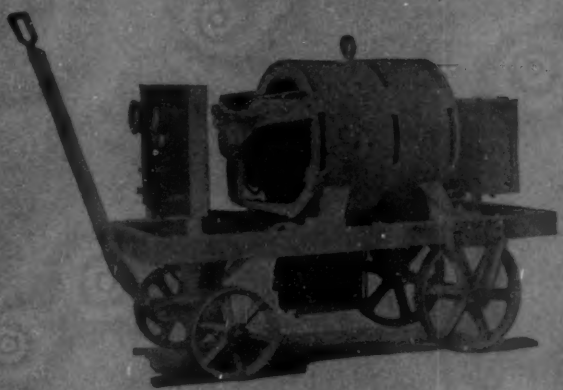

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